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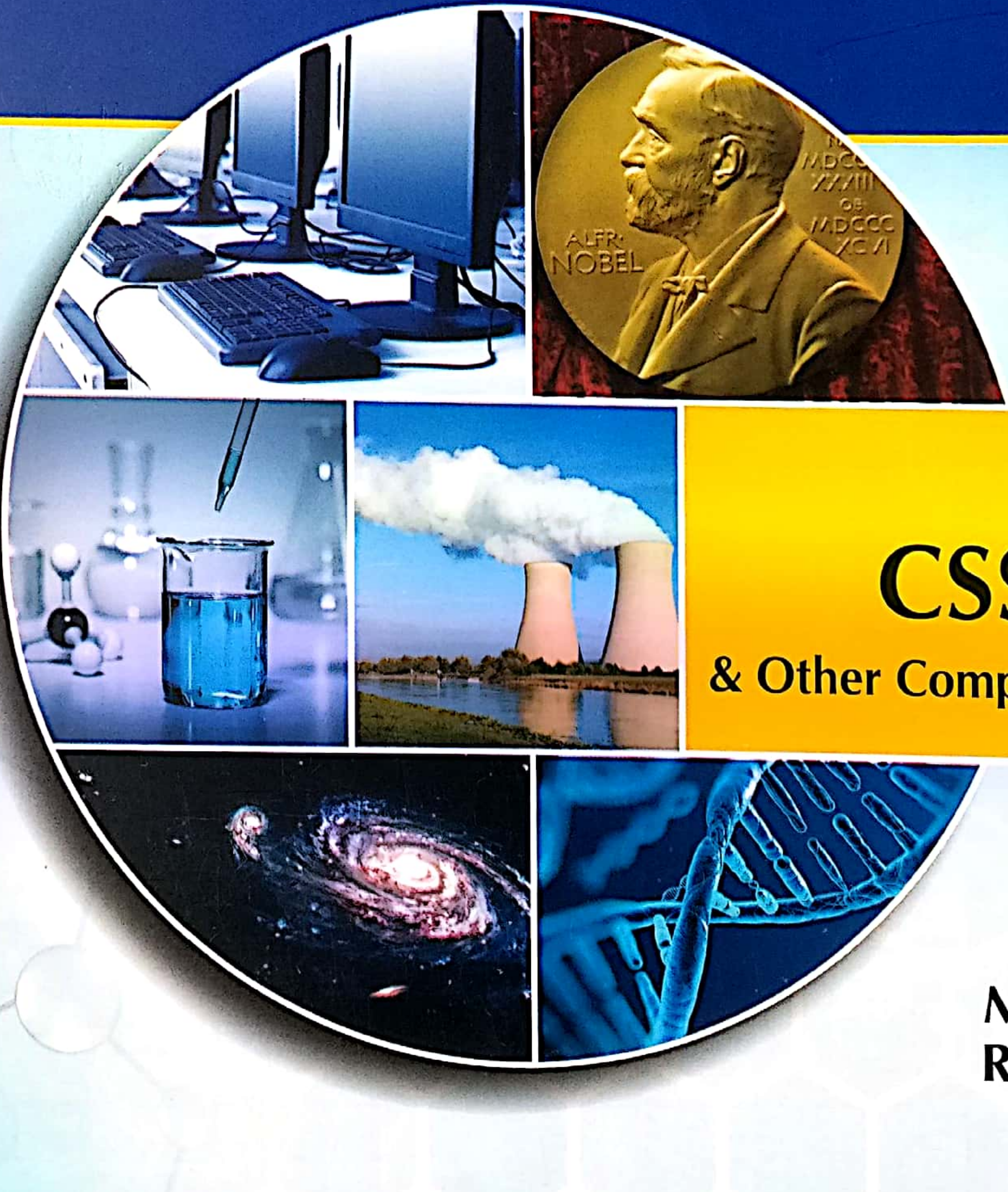

Revised Edition

for
CSS, PMS
& Other Competitive Exams

Mian Shafiq
Rabbia Saher

DEDICATION

Dedicated to the Creator and to His beloved Prophet Muhammad ﷺ

خَلَقَ السَّمٰوٰتِ وَالْاَرْضَ بِالْحَقِّ ۚ يُكَوِّرُ الَّيْلَ عَلَى النَّهَارِ وَيُكَوِّرُ النَّهَارَ عَلَى
الَّيْلِ وَسَخَّرَ الشَّمْسَ وَالْقَمَرَ ۭ كُلٌّ يَّجْرِيْ لِاَجَلٍ مُّسَمًّى ۭ اَلَا هُوَ الْعَزِيْزُ الْغَفَّارُ ۝٥

"He created the heavens and the earth with truth. He makes the night to go in the day, and makes the day to go in the night. And He has subjected the sun and the moon. Each running (on a fixed course) for an appointed term. Verily, He is the All-Mighty, the Oft-Forgiving."

(***Surah Al-Zumar: 5***)

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Part–I

General Science

CHAPTER 1

ASTRONOMY

"And yet it moves," Galileo Galilee

Astronomy is the study of the universe and the celestial bodies, gas and dust within it. Astronomy includes observations and theories about the solar system, the stars, the galaxies and the general structure of space. The vast empty space around us that consists of stars, solar system, galaxies etc. is called Universe. It is defined as sum total of all matter and energy that exists or has existed both in space and time. The **universe** can also be defined as "the totality of everything that exists, including all matter and energy, the planets, stars, galaxies and the contents of intergalactic space."

ASTRONOMICAL SYSTEM OF UNITS

The astronomical system of units is a system of measurement developed for use in astronomy. It was adopted by the International Astronomical Union (IAU) in 1976 and has been significantly updated in 1994 and 2009. The system was developed because of the difficulties in measuring and expressing astronomical data in International System of Units (SI units). The astronomical system of units is a tri-dimensional system, in that it defines units of length, mass and time only.

Astronomical Unit of Time

The astronomical unit of time is **the day,** defined as 86400 seconds. 365.25 days make up one Julian year. The symbol D is used in astronomy to refer to this unit.

Astronomical Unit of Mass

The astronomical unit of mass is the **solar mass.** The solar mass, 1.98892×10^{30} kg, is a standard way to express mass in astronomy, used to describe the masses of other stars and galaxies. It is equal to the mass of the Sun.

Astronomical Units of Length

An **astronomical unit (AU)** is defined as the average distance between the Earth and the Sun and it is approximately 150 million kilometres or exactly 149,597,870,700 metres. Astronomical unit, light-year and parsec are the units for measuring huge distances.

A **light-year** is the distance that light can travel in one year in a vacuum, which is about 5.8×10^{12} miles or 63,240 AU or 9.46053×10^{12} kilometres.

A **parsec** is a unit of distance that is equal to 3.26 light years or 3.085678×10^{13} kilometres. It is the distance at which a star would have a parallax of 1 second of arc.

ORIGIN OF THE UNIVERSE

> *"The problem of the origin of the universe is a bit like the old question: Which came first, the chicken, or the egg. In other words, what agency created the universe? And what created that agency? Or perhaps, the universe, or the agency that created it, existed forever, and didn't need to be created."* ***(Stephen Hawking)***

The Big Bang Theory is the leading explanation about how the universe began. At its simplest, it talks about the universe as we know it starting with a small singularity, then inflating over the next 13.7 billion years to the cosmos that we know today. Because current instruments don't allow astronomers to peer back at the universe's birth, much of what we understand about the Big Bang Theory comes from mathematical theory and models.

Big Bang Theory

Most astronomers believe the universe began in a Big Bang about 13.7 billion years ago. At that time, the entire universe was inside a bubble that was thousands of times smaller than a pinhead and it was named as **singularity**. It was hotter and denser than anything we can imagine.

Then it suddenly exploded. The universe that we know was born. Time, space and matter all began with the Big Bang. In a fraction of a second, the universe grew from smaller than a single atom to bigger than a galaxy. And it kept on growing at a fantastic rate. It is still expanding today.

Nicolas Copernicus

Nicolas Copernicus proposed a heliocentric (sun-centred) model for the solar system, in which the Sun is stationary at the centre and Earth and the other planets orbit around it. Before Copernican theory was accepted, astronomers believed that Earth was stationary at the centre of the solar system, and the Sun and planets revolved around it. Italian physicist and astronomer Galileo attempted to publicize Copernican theory in the early 1600s, and was convicted as a result. Copernican theory was not widely accepted until the late 17th century.

As the universe expanded and cooled, energy changed into particles of matter and anti-matter. These two opposite types of particles largely destroyed each other. But some matter survived. More stable particles called protons and neutrons started to form when the universe was one second old. Over the next three minutes, the temperature dropped below 1 billion degrees Celsius. It was now cool enough for the protons and neutrons to come together, forming hydrogen and helium nuclei.

After 300000 years, the universe had cooled to about 3000 degrees. Atomic nuclei could finally capture electrons to form atoms. The universe was filled with clouds of hydrogen and helium gas. These clouds of dust and gases formed all celestial bodies afterwards.

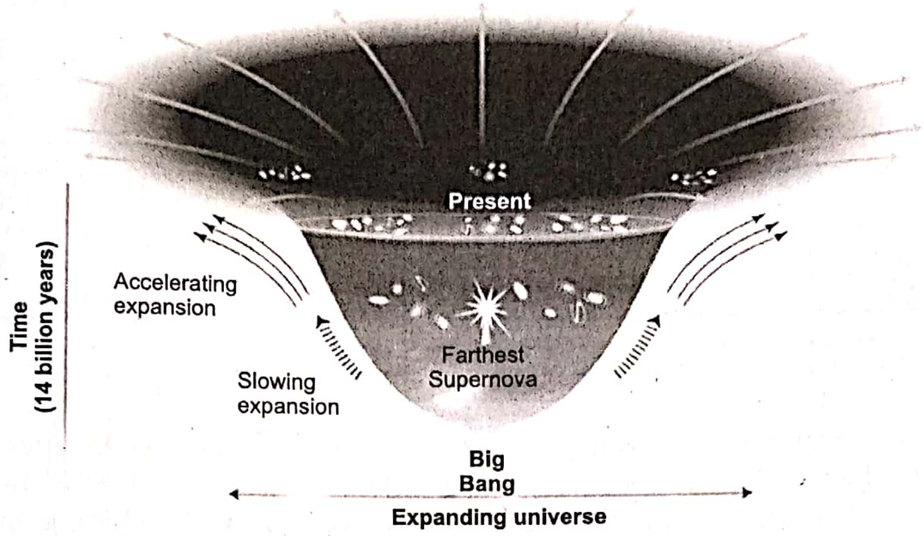


Figure: Big Bang

Evidence for the Big Bang

By analysing the spectrum of light from a star or galaxy, astronomers can tell how fast it is moving, and whether it is moving towards Earth or away from Earth. If an object is moving away from Earth, its light shifts to longer, redder wavelengths, an effect known as **red shift**. If an object is moving towards Earth, its light shifts to shorter, blue wavelengths, an effect known as **blue shift**. Red shift supports the big bang theory.

The light from distant galaxies is red shifted (this tells us the galaxies are moving away from us) and the further away the galaxy the greater the red shift (this tells us that the more distant the galaxy the faster it is moving).

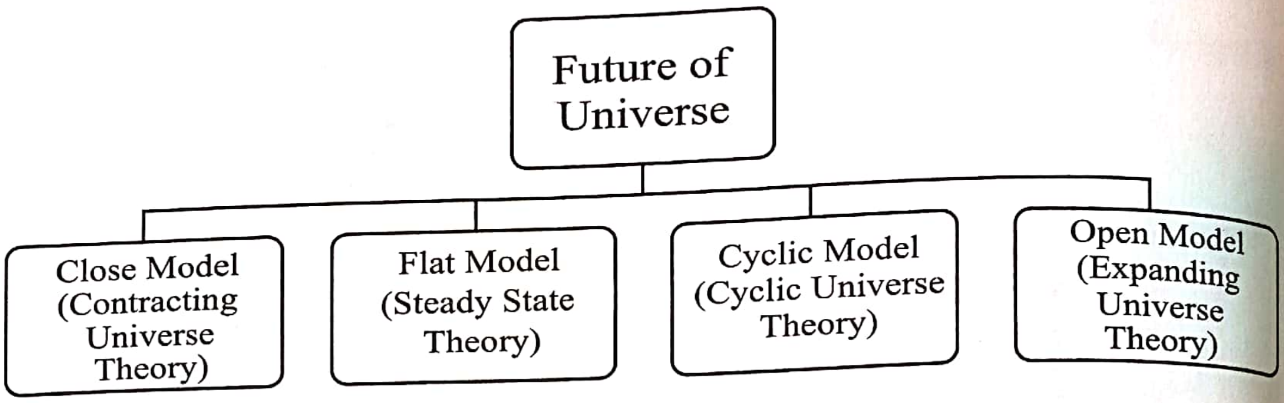
A second piece of evidence that supports the big bang theory is cosmic background microwave radiation. Arno Penzias and Wilson detected a **cosmic microwave background radiation** while studying radio signals. These radiations are received from all parts of the universe and is thought to be the heat left over from the original expansion or big bang.

Some of the other theories argue that the Big Bang theory is based on a false premise. Some, instead, prefer to build theories on a static universe, which is what was originally predicted by Einstein's theory of general relativity.

The Ultimate Fate of the Universe

Once the notion that the universe started with a rapid expansion nicknamed the Big Bang became accepted by the majority of scientists, the ultimate fate of the universe became a valid cosmological question, one depending upon the physical properties of the mass/energy in the universe, its average density, and the rate of expansion.

There is a growing consensus among cosmologists that the universe is flat and will continue to expand forever. The ultimate fate of the universe is dependent on the shape of the universe and what role dark energy will play as the universe ages. Astronomers recognize four models of possible futures for the universe.


Future of Universe
Close Model (Contracting Universe Theory)
Flat Model (Steady State Theory)
Cyclic Model (Cyclic Universe Theory)
Open Model (Expanding Universe Theory)

GALAXY

A galaxy is a gravitationally bound system of stars, stellar remnants, interstellar gas, dust, and dark matter. The word galaxy is derived from the Greek *galaxias*, literally "milky", a reference to the Milky Way. Astronomers estimate that there about 100 to 200 billion galaxies exist in the observable universe. Milky Way and Andromeda are the examples of galaxy.

Galaxies range in size from dwarfs with just a few thousand stars to giants with one hundred trillion stars, each orbiting their galaxy's own centre of mass. Galaxies are categorized according to their visual morphology, including elliptical, spiral, and irregular. Many galaxies are thought to have black holes at their active centres. A **black hole** is a massive object (or region) in space that is so dense that within a certain radius, its gravitational field does not let anything escape from it, not even light.

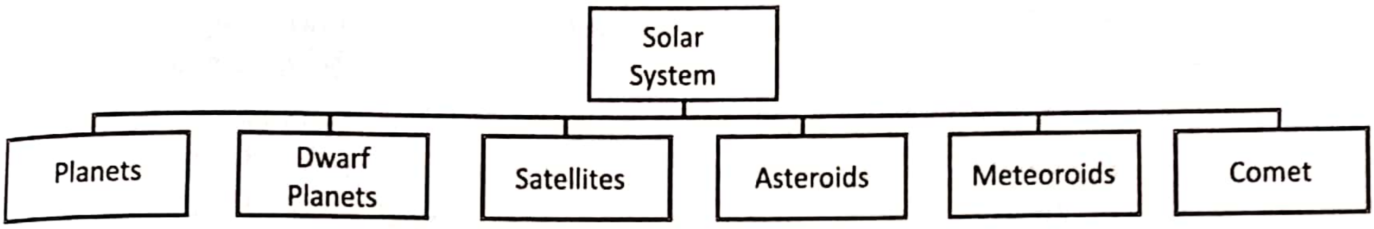
Milky Way

Milky Way is the large, disk-shaped galaxy that includes our solar system. A spiral galaxy is shaped like a disk, usually with a bulge in the centre and with arms that spiral outwards as the galaxy rotates. In addition to the Sun, the Milky Way contains about 200-400 billion other stars. Most of the stars that we can see are in the Milky Way Galaxy. The Milky Way looks like a faint band of white in the night sky. Main features of Milky Way Galaxy are the following:

1. The Milky Way is about 100,000 light years in diameter.
2. This spiral galaxy formed about 13.7 billion years ago.
3. Sun takes roughly 250 million years to orbit around the Milky Way.
4. Our solar system is about 30,000 light years away from the centre of the Milky Way galaxy.
5. The major arms of the Milky Way galaxy are the Pursues Arm, Sagittarius Arm, Centaurs Arm and Cygnus Arm.
6. Our Solar System is in a minor arm called the Orion Spur/ Orion Arm.
7. The region in space occupied by Milky Way is called Galactic Plane.
8. Nearest galaxy to Milky Way Galaxy is Andromeda.
9. Our Milky Way is the part of cluster of three dozens of galaxies called 'Local Group'.

SOLAR SYSTEM

Our solar system consists of the sun, planets, dwarf planets, moons, an asteroid belt, comets, meteors and other objects. The Sun is the centre of our solar system and all other objects in the solar system orbit the Sun. Our solar system is elliptical in shape, which means that it is shaped like an egg. The Sun is the biggest object in our solar system and contains more than 99% of the solar system's mass.



Our Solar System is around 4.5 billion years old. It formed out of a huge cloud of gas and dust called the solar nebula. Under gravity, the cloud collapsed and the material formed the Sun and a disc of matter in which the planets were born.

The Sun

Sun is a star. A **star** is a huge ball of gas, mostly hydrogen and helium. Nuclear fusion reactions inside the star release enormous amounts of energy. Stars are very hot and give off their own light. This is why, we can see the Sun during the day, and distant stars in the night sky. Scientists usually divide Sun into three main regions: the Sun's interior, the solar atmosphere, and the visible "surface" of the Sun which lies between the interior and the atmosphere.

There are three main parts of the Sun's interior: **the core, the radiative zone,** and **the convective zone.** The core is at the centre. It is the hottest region, where the nuclear fusion reactions that power the Sun occur. The Core of the sun is considered to extend from the centre to about 25% of the solar radius. It has a density of about 150 times the density of water. The Core is the only section of the sun that produces heat through fusion. The temperature is 15 million degree Celsius.

Do You Know?

Proxima Centauri is closest star to the earth after sun and is 40 trillion km away.

Moving outward, next comes the **radiative (or radiation)** zone. Its name is derived from the way energy is carried outward through this layer, carried by photons as thermal radiation. The Radiative material is hot and dense enough that thermal radiation (not fusion) transfers the intense heat of the Core outward.

The third part of the solar interior is named the convective (or convection) zone. It is also named after the dominant mode of energy flow in this layer; heat moves through upward convection. The convection plasma is not dense or hot enough to transfer the heat energy of the interior outward through radiation. As a result, thermal convection occurs. Once the material cools off at the surface, it plunges downward to the base of the convective zone, to absorb more heat from the top of the radiative zone and then repeats the cycle.

The boundary between the Sun's interior and the solar atmosphere is called the **photosphere.** It is what we see as the visible "surface" of the Sun. The photosphere is not like the surface of a planet. Sun also has an atmosphere. The lower region of the solar atmosphere is called the **chromosphere.** Its name comes from the Greek root *chroma* (meaning color), for it appears bright red when viewed during a solar eclipse. A thin transition region, where temperatures rise sharply, separates the chromosphere from the vast corona above. The uppermost portion of the Sun's atmosphere is called the **corona,** and is surprisingly much hotter than the Sun's surface (photosphere)!

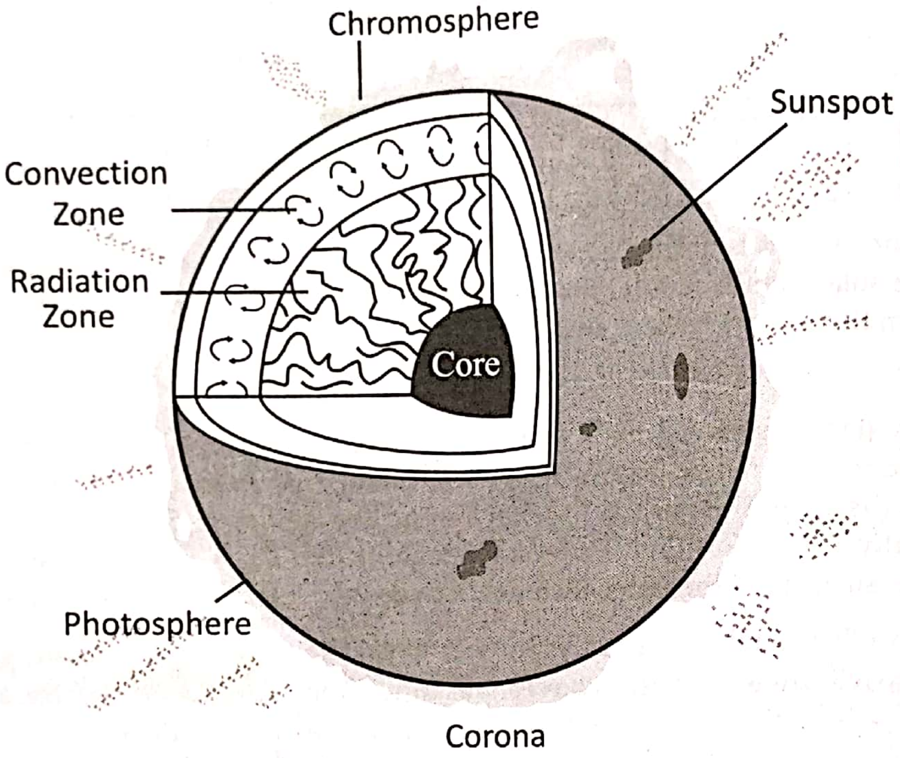


Figure: Structure of the Sun

Important Physical Features of the Sun

1. Diameter of sun is 1,391,940 km (870,000 miles).
2. Mass of sun is 1.989 x 10^{30} kg or 330,000 times of Earth.
3. Sun is composed of 74% H_2, 24% He and 2% heavy metals on the basis of percentage of total mass.
4. Density of sun is 1.41 g/cm^3.
5. Temperature at Core of the sun is 15 million C° (27.5 million °F) and at surface of sun is 5500 °C (9932°F).
6. Mean distance from earth is 150 million km or 93 million miles.
7. Sun has very large and active magnetic field.
8. Sun is moving around the centre of galaxy at a velocity of 220 km/s. It revolves around Milky Way in about 250 million years.
9. Sun's rays reach earth surface in 8 minutes and 20 seconds.

PLANETS

Planet is the term used for a body in orbit around the Sun. The word comes from the Greek *planetes*, which means "wanderers." Our solar system has eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Pluto, which was considered a planet some years back, is now classified as dwarf planet.

Mnemonic Device for Planets

My very educated mother just servea us noodles. Mercury, Venus, Earth, Mass, Jupiter, Saturn Uranus and Neptune.

Mercury, Venus, Earth and Mars are the planets closest to the Sun. They are called the inner planets. The **inner planets** are made up mostly of rock. Therefore, they are also called rocky or terrestrial planets. They are very small as compared to the outer planets, therefore, also called inferior planets.

Jupiter, Saturn, Uranus and Neptune are outer planets also called **Jovian** (Jupiter like) planets because these are large in size. All outer planets are also called gaseous planets because they have an atmosphere of hydrogen and helium and they are have rings.

Terrestrial Planets	Jovian Planets
Mercury, Venus, Earth and Mars	**Jupiter, Saturn, Uranus, and Neptune**
• Close to Sun	• Far from Sun
• Small masses and radii	• Large masses and radii
• Rocky, solid surfaces	• Gaseous surface
• High densities	• Low densities
• Slow rotation	• Fast rotation
• Weak magnetic field	• Strong magnetic field
• No rings	• Many rings
• Few moons	• Many moons

Physical Characteristics of Planets

Mercury

Mercury is smallest and fastest revolving planet. Its diameter is 4900 km. Mercury is about the same size as our Moon. It is closest to the Sun. It was named after Mercury, the swift messenger of the gods in ancient Roman mythology.

1. Mercury has no atmosphere; therefore, humans would not be able to live there.
2. The surface of Mercury has holes in it where objects such as meteorites and asteroids crash into it.
3. It is made of dense rocky materials, therefore, has very high density.
4. Mercury revolves around sun in 88 days.
5. It is 58 million km away from sun.
6. Its temperature varies from -170 to 450°C.

Venus

Venus is the hottest and brightest planet. Here temperature rises to 460-480 degrees Celsius on the side facing the Sun. Venus has very thick, rapidly spinning clouds of CO_2 which cover its surface. These clouds hold heat in it that is why Venus gets so hot. These clouds also reflect sunlight that is why Venus appears so bright. Venus is almost equal the size of earth,

Therefore, it is termed as *sister planet of earth.*

1. Venus has several large inactive volcanoes.
2. Venus rotates from east to west while all other planets rotate from west and east.
3. Venus spins very slowly. One day of Venus is equal to 243 earth days.
4. Venus's revolution period is 225 days.
5. It has no rings and no moons.

Morning Star

When Venus is visible in the morning, it reaches its maximum brightness shortly before sunrise, and when it is visible in the evening, it reaches its maximum brightness just after sunset — that is why Venus got the names Morning Star and Evening Star.

Earth

Earth is the most colourful and the densest planet The Earth is the biggest of all the terrestrial planets. It is third in position and fifth largest in solar system. Venus is the closest planet to Earth. The diameter of earth is 12756 km or 7,926 miles. The circumference measured around the equator is 24,901 miles or 40,075 km. Earth is the only planet of solar system which can support life.

1. About 30% of the Earth's surface is covered with land, while about 70% is covered by oceans.
2. The Earth has one moon. Its name is Luna.
3. It has an atmosphere made up of many different gases, mainly nitrogen and oxygen.
4. Earth complete one revolution around sun in 365 days.
5. The Earth rotates around its axis and it takes 23 hours 56 minutes and 4 seconds (one day) to spin around its axis.
6. Earth is the densest planet; its density is 5.52 g/cm^3.

Mars

Mars is the second smallest planet. Mars is called red planet due to the presence of red dust. The temperature on Mars can be very, very cold. At the top and bottom of the planet are poles just like on Earth. Mars has average temperature of -30°C. Mars surface is very interesting as it has many craters which were formed by meteorites or asteroids hitting it. Mars also has some of the tallest Mountains and some of the deepest valleys in our solar system.

1. Mars has two moons, Phobos and Deimos, which have unusual shapes.
2. Mars atmosphere is composed of CO_2.
3. Mars diameter is 6780 km.
4. Mars is 228 million km away from sun.
5. Its rotation period is 24 hours and 40 minutes.
6. Its revolution period is 687 days.

Jupiter

Jupiter is the biggest and fastest rotating planet. Huge storms of swirling gases can be found in Jupiter's atmosphere. The largest storm of gas is called the Great Red Spot. Large bolts of lightning have also been seen in Jupiter's atmosphere. It is 1350 times bigger than earth in volume and 318 times massive than earth.

1. Jupiter has 67 moons.
2. Ganymede is the largest moon of Jupiter and is the largest in our solar system.
3. One day of the Jupiter is equal to 9 hours and 55 minutes of the earth.
4. Its revolution period is 11.86 years.
5. It has rings which are not so visible.
6. Average temperature of the Jupiter is -150°C.

Saturn

Saturn is the second biggest planet and is also called Ring Planet. Saturn is surrounded by rings made of ice and dust. Its rotation period is 10 hrs and 15 minutes and is second fastest rotating planet. Saturn is a very large gaseous planet which spins very rapidly on its axis. Saturn's atmosphere has winds which can blow at over 1800 kilometres per hour. The white spots on Saturn are believed to be powerful storms. Saturn has a density of 0.71 grams/cubic centimetre. Since Saturn is less dense than water, it would actually float like an apple if you could find a pool large enough.

1. Saturn has 62 moons.
2. Titan (Saturn's Moon) is the second largest moon of our solar system.
3. Its diameter is 120,800 km.
4. Its distance from sun is 1430 million km.
5. Its average temperature is -180°C.

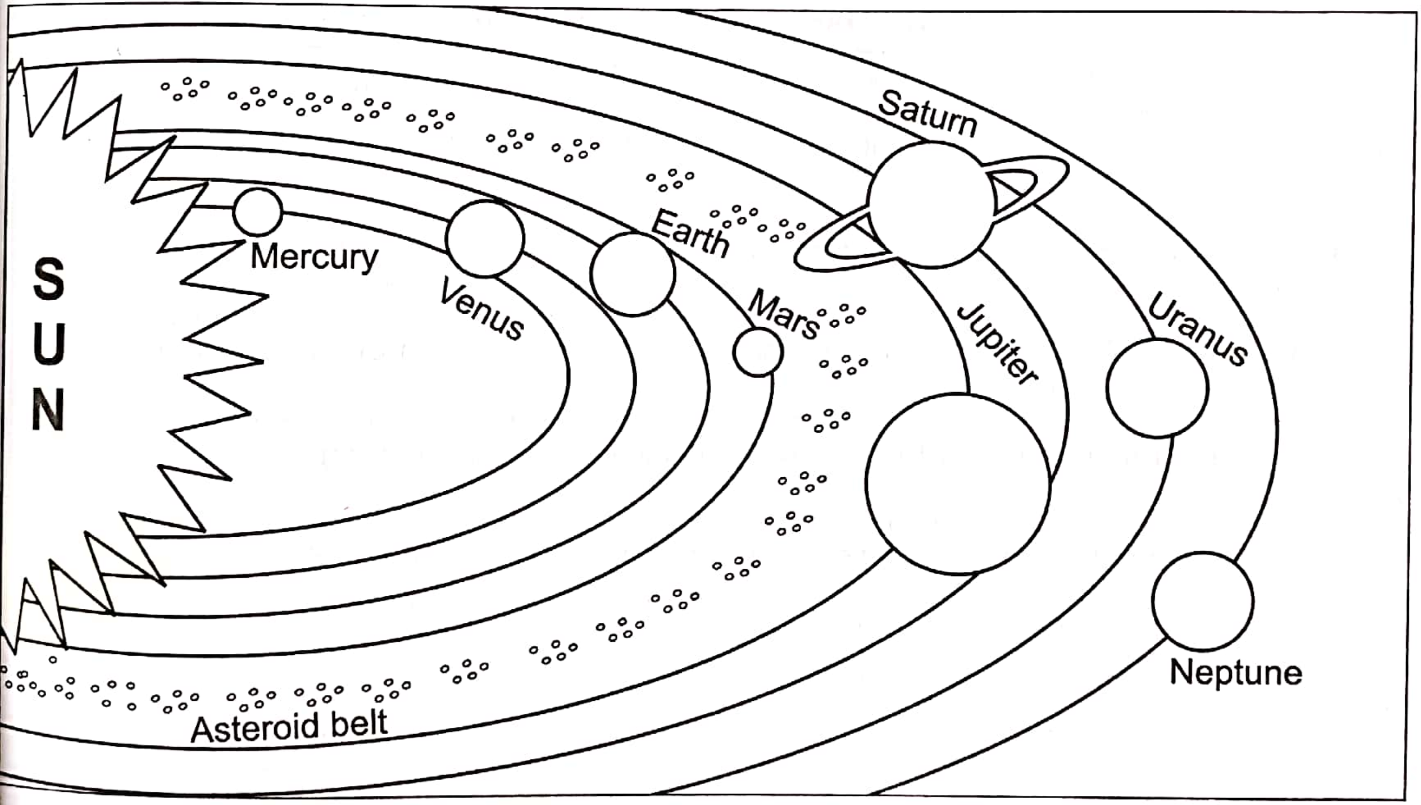


Figure: Planets Revolving around Sun

Uranus

Uranus is called Green Planet because its atmosphere is made up of hydrogen, helium and methane. The temperature in the upper atmosphere is very cold. The rapid rotation of Uranus causes winds up to 600 kilometres per hour to blow in its atmosphere.

1. Uranus has 13 known rings which contain dark, boulder-sized particles.
2. Uranus has 27 moons.
3. Its rotation period is of 17 hours.
4. Its revolution period is equal to 84 earth years.
5. Its mean distance from sun is 2870 million km.
6. Its diameter is 5180 km.

Neptune

Neptune is the farthest planet from the Sun. Neptune is the coldest and slowest revolving planet. Its orbital period is of 165 years. Neptune and Uranus are called twin planets. Neptune has winds in its atmosphere which blow at over 2000 kilometres per hour. This planet has large, dark circles on its surface which astronomers believe to be storms.

1. Neptune has two thick and two thin rings surrounding it.
2. Neptune also has 14 known moons.
3. The period of rotation is about 16 hours.
4. Its diameter is 49,400 km.
4. It is 4500 million km away from sun.
5. Its biggest moon Triton is the sixth largest moon of our solar system.

Difference between a Star and a Planet

Star	Planet
Star is a massive shining sphere of hot gas.	Planet is a round body in space that orbits a star.
A star shines by releasing light produced by nuclear fusion.	Planets do not produce light.
Different heavenly objects revolve around star such as planet, dwarf planet, asteroid, etc.	Objects that revolve around planets are called satellites (moon).
Stars revolve around the centre of their galaxy.	Planets revolve around star.
Stars have very high temperature like sun has a surface temperature of 5500 to 6000°C.	Planets drive energy and heat from sun, therefore, the ones near to sun are hotter.
Example are Sun, Proxima Centauri, Antares and Pistol Star.	Example are Earth, Venus, Mars, Jupiter, etc.

Planets Physical Features Chart

Name of the planet	Distance from the sun (million km)	Diameter (km)	Period of revolution (earth time)	Period of rotation (earth time)	Average temperature °C	Mean Density g/cc (water=1)	Atmospheric composition	No of moons	Rings	Prominent Features
Mercury	58	4900	88 days	59 days	-170 to 450	5.43	No air	0	No	Smallest & fastest revolving planet
Venus	110	12100	225 days	243 days	480	5.25	CO_2	0	No	Hottest, brightest & morning/ evening star
Earth	150	12756	365.25 days	24 hours	15	5.52	N_2 & O_2	1	No	Heaviest and most dense planet
Mars	228	6780	1.88 years	24 hours & 40 minutes	-30	3.93	CO_2	2	No	Red plane & second smallest planet
Jupiter	780	142800	11.86 years	9 hours & 55 minutes	-150	1.33	H_2 & He	67	Yes	Biggest, most massive & fastest rotating planet
Saturn	1430	120800	29.46 years	10 hours & 15 minutes	-180	0.71	H_2 & He	62	Yes	Ring planet, least dense & second largest planet
Uranus	2870	51800	84 years	17 hours	-210	1.24	H_2 & He	27	Yes	Green planet
Neptune	4500	49400	164.79 years	16 hours	-220	1.67	H_2 & He	14	Yes	Coldest and slowest revolving planet

Note: Figures are rounded off for the ease of students.

DWARF PLANETS

The International Astronomical Union (IAU) has defined a planet as a celestial body that:

- is in orbit around a star, but is not itself a satellite;
- has sufficient mass so it is nearly spherical in shape; and
- has cleared the neighbourhood around its orbit.

On the other hand, a dwarf planet is defined as a celestial body that:

- is in orbit around a star, but is not itself a satellite; and
- has sufficient mass so it is nearly spherical in shape;
- has not cleared the neighbourhood around its orbit,

The only difference between a planet and a dwarf planet is the area surrounding each celestial body. A dwarf planet has not cleared the area around its orbit, while a planet has. Dwarf planet could not do so because of small size and less gravitational pull. There are five officially recognised dwarf planets in our solar system. They are Ceres, Pluto, Haumea, Makemake and Eris. With the exception of Ceres, which is located in the asteroid belt, the other dwarf planets are found in the outer solar system i.e. *Kuiper Belt*.

Pluto is considered to be a dwarf planet because objects in the Kuiper Belt are within its orbit and it is unable to attract them. For many years, Pluto was thought of as the farthest known planet from the Sun. Pluto has five moons.

MOON

Natural satellite is a body in space that orbits a larger body (planet). The larger body is referred to as the satellite's primary. Natural satellites that orbit planets are often called moons. Our moon named 'Luna' is the fifth largest moon in the solar system. Its diameter is 3475 km and its mass is 7.3 x 10^{22} kg (1/81 of earth). Its density is 3.347 g/cm^3. The average distance of the Moon from the Earth is 384,400 kilometres (238,857 miles). The Moon orbits the Earth every 27 days and 7 hours.

1. The effect of gravity on moon surface is one-sixth of earth's gravity.
2. The average surface temperature of the Moon is 107 degrees Celsius during the day and -153 degrees Celsius at night.
3. Moon has no atmosphere but it has negligible amount of inert gases.
4. It takes 1.3 seconds to moonlight to reach the earth.
5. Moon is one-fourth the size of its mother planet, i.e. earth.

SOLAR AND LUNAR ECLIPSE

An eclipse takes place when one heavenly body such as a moon or planet moves into the shadow of another heavenly body. There are two types of eclipses on Earth: an eclipse of the moon and an eclipse of the sun.

Lunar Eclipse

The moon moves in an orbit around Earth, and at the same time, Earth orbits the sun. Sometimes Earth moves between the sun and the moon. When this happens, Earth blocks the sunlight that normally is reflected by the moon. (This sunlight is what causes the moon to shine.) Instead of light hitting the moon's surface, Earth's shadow falls on it. This is an eclipse of the moon -- a lunar eclipse. A lunar eclipse can occur only when the moon is full. A lunar eclipse can be seen from Earth at night.

The earth casts a long, conical shadow in space. At any point within that cone the light of the sun is wholly obscured. Surrounding the shadow cone, also called the **umbra,** is an area of partial shadow called the **penumbra.** A lunar eclipse usually lasts for a few hours. At least two partial lunar eclipses happen every year, but total lunar eclipses are rare. It is safe to look at a lunar eclipse.

Three Types of Lunar Eclipses

- **Penumbral lunar eclipse** — the Moon only passes through the penumbra of Earth's shadow. It is rarely visible from earth as there is slight change of colour of the moon.
- **Partial lunar eclipse** — when part of the Moon passes through the umbra of Earth's shadow then it is termed as partial lunar eclipse as its whole area is not obscured by the shadow.
- **Total lunar eclipse** — when the entire Moon passes through the umbral region of Earth's shadow and moon is totally obscured.

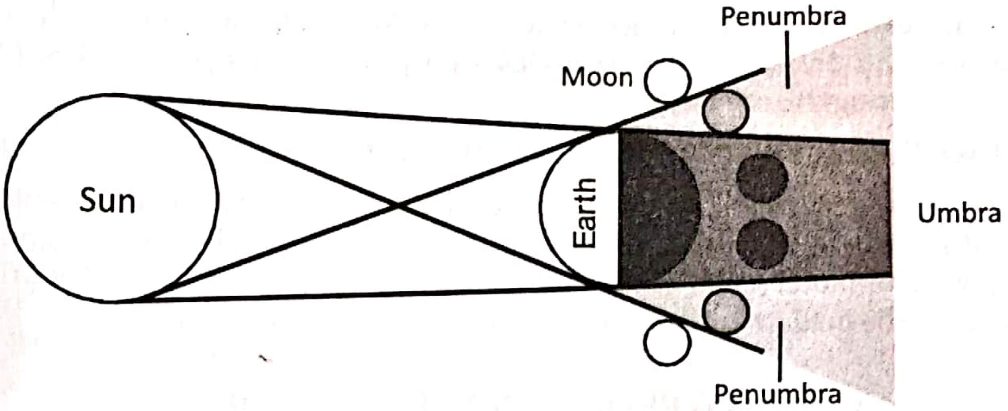


Figure: Lunar Eclipse

Solar Eclipse

Sometimes when the moon orbits Earth, it moves between the sun and Earth. When this happens, the moon blocks the light of the sun from reaching Earth. This causes an eclipse of the sun, or solar eclipse. During a solar eclipse, the moon casts a shadow onto Earth. This shadow on the Earth consists of two regions: the umbra and the penumbra. Solar eclipses happen once every 18 months. Unlike lunar eclipses, solar eclipses only last for a few minutes. Solar eclipse always occurs at the time of new moon.

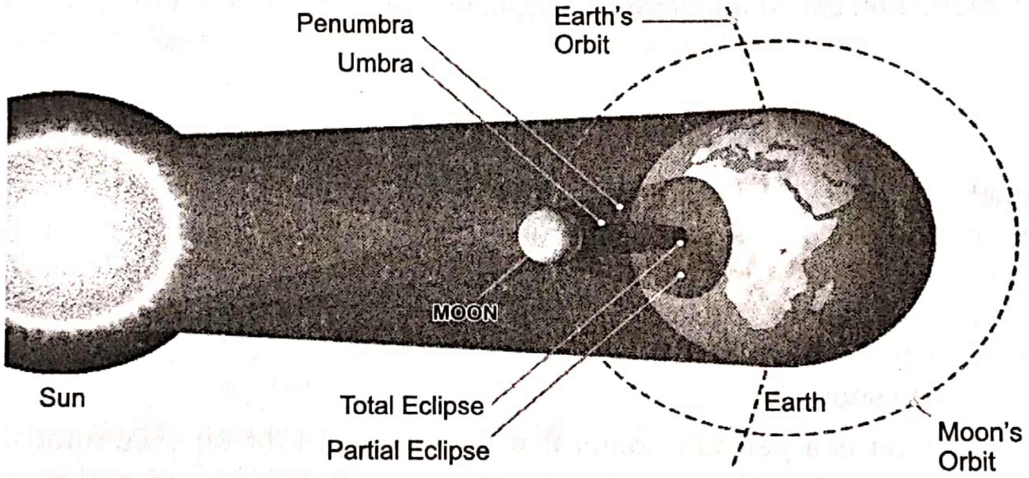


Figure: Solar Eclipse

NEVER look directly at the sun: It can permanently damage your eyes! You must use proper safety equipment to look at any type of solar eclipse.

Types of Solar Eclipse

- A **total solar eclipse** occurs when the Moon completely covers the Sun, as seen from Earth. Totality during such an eclipse can only be seen from a very small area on Earth. This area is usually about 100 miles (160 km) wide and 10,000 miles (16,100 km) long. Areas outside this track may be able to see a partial eclipse of the Sun. Looking at a solar eclipse without any protective eyewear can severely harm one's eyes.
- A **partial solar eclipse** can be observed when the Earth, Moon and Sun do not align in a perfectly straight line, and the Moon only partially covers the disc of the Sun.

- An **annular solar eclipse** occurs when the Moon appears smaller than the Sun as it passes centrally across the solar disk and a bright ring, or annulus, of sun remains visible during the eclipse.

Why don't we have a lunar eclipse every month?

You might be wondering why we don't have a lunar eclipse every month as the moon orbits Earth. It's true that the moon goes around Earth every month, but it doesn't always get in Earth's shadow. The moon's path around Earth is tilted compared to Earth's orbit around the sun. The moon can be behind Earth but still get hit by light from the sun.

ASTEROIDS AND METEOROIDS

Asteroids are the largest non-planetary and non-lunar objects in the solar system. These objects are larger than 100 metres in diameter (IAU has not defined any size dimensions) and less than 1000 km in diameter. The largest asteroid is Ceres, with a diameter of 950 km. They are generally irregular in shape and often have surfaces covered with craters. These are also named as *minor planets* or *Planetoids*. Most of them orbit between the orbits of Mars and Jupiter.

A *meteoroid* is a small body travelling through space. These bodies typically originate from comets and asteroids. There is no well defined size range for a meteoroid. However, we usually refer to a meteoroid as a piece of matter, which when it strikes the Earth's atmosphere, produces the visual phenomenon called a **meteor**. A fragment that survives to hit the ground is known as a **meteorite**.

COMET

A **comet** is a celestial body that orbits around the sun. It is made up of a nucleus (solid, frozen ice, gas and dust), a gaseous coma (water vapour, CO_2 and other gases) and a tail (dust and ionized gases). Its long tail of gas and dust always points away from the sun, because of the force of the solar wind. The tail can be up to 250 million km long. Comets are only visible when they're near the sun in their highly eccentric orbits. When comets are farthest from sun, they are named dirty snowball.

Halley's Comet is a periodic comet that orbits around the sun. Edmund Halley was the first person to recognize that it is periodic. It was last seen in 1986 and will be seen next in the year 2061; its period is 75 years.

CONSTELLATION

Constellations are groups of stars visible within a particular region of the night sky forming various shapes and patterns. Constellations have been named after the names of animals, tools and objects. Some other constellations have been named after religious personalities and scientists. Constellations can be viewed after sunset and before sunrise. There are total 88 named constellations. The largest one is Hydra. Other examples include Ursa Major, Ursa Minor, Canis Major and Canis Minor.

ASTRONOMY (MCQS)

Note: Answers are Bold and Underlined.

1. **What is the mass of the Sun?**
   (a) 1.5 x 10^{30} kg
   (b) **1.98 x 10^{30} kg**
   (c) 4.5 x 10^{30} kg
   (d) 8 x 10^{30} kg
2. **What is the temperature at the centre of the Sun?**
   (a) 6 million °C
   (b) 10 million °C
   (c) **15 million °C**
   (d) 20 million °C
3. **The top atmosphere of the Earth directly reflects back into space nearly what part of the total amount of sun's energy coming to it?**
   (a) 10%
   (b) 20%
   (c) **30%**
   (d) 50%
4. **The phases of the moon are partially the result of the:**
   (a) Changes in the shape of the moon
   (b) **Revolution of the moon around the earth**
   (c) Variations in the moon's gravitation
   (d) Variation in the speed of rotation of the moon
5. **Constellations referred to as zodiac, are:**
   (a) **Imaginary regions that encompass the path of the planets**
   (b) Signs of Roman gods
   (c) A group of stars
   (d) None of these
6. **'Black holes' refers to:**
   (a) Holes occurring in heavenly bodies
   (b) Bright spots on the sun
   (c) **Collapsing object of high density**
   (d) Collapsing object of low density
7. **Which one of the following is not a unit of distance?**
   (a) Parsec
   (b) Astronomical Unit
   (c) Light Year
   (d) **Foot Candle**
8. **Which one of the following planets orbits around the sun in a clockwise direction?**
   (a) Earth
   (b) Mercury
   (c) Jupiter
   (d) **Venus**
9. **Isobars are the lines connecting the places having same:**
   (a) **Pressure**
   (b) Rainfall
   (c) Height
   (d) Temperature
10. **Spring tides occur on new moon and full moon days because on these days:**
    (a) **Sun, moon and earth are in a straight line**
    (b) Sun and earth are at right angles
    (c) Sun and moon are at right angles
    (d) Earth and moon are at right angles
11. **The position of earth in its orbit, when it is at its greatest distance from sun is called:**
    (a) **Aphelion**
    (b) Perihelion
    (c) Perigee
    (d) Apogee
12. **Which of the following planets is fastest rotating planet?**
    (a) Mercury
    (b) Mars
    (c) **Jupiter**
    (d) Venus

13. **Which of the following planets has the smallest diameter?**
(a) Mercury (b) Mars (c) Pluto (d) Venus

14. **Which of the following is the largest planet?**
(a) Neptune (b) Jupiter (c) Saturn (d) Mars

15. **The most abundant element in the earth's crust is:**
(a) Oxygen (b) Aluminium (c) Iron (d) Silicon

16. **Who was the first to measure earth's radius?**
(a) Galileo (b) Copernicus (c) Ptolemy (d) Eratosthenes

17. **Name the nearest star to our sun.**
(a) Proxima Centurai (b) Alpha Scorpii (c) Beta Orionis (d) Vega

18. **Name the nearest regular galaxy to our milky way:**
(a) NGC 185 (b) Small Magellanic (c) Magellanic Cloud (d) Andromeda

19. **The lunar eclipse occurs when:**
(a) Moon is between the earth and the sun
(b) Earth is between the sun and the moon
(c) Sun is between the earth and the moon
(d) Earth is at right angles to the direction of the sun and the moon

20. **Most important effect of moon on earth is that it:**
(a) Causes weather change (b) Causes earthquakes
(c) Causes solar and lunar eclipse (d) Effects tides of the ocean

21. **Among the planets of the Solar system the position of the Earth from the Sun is:**
(a) Second (b) Third (c) Fourth (d) Fifth

22. **Hailey's comet is visible after every:**
(a) 84 years (b) 76 years (c) 1000 years (d) 365 years

23. **Which of the following spacecraft enabled man to step on the moon first?**
(a) Sputnik I (b) Luna II (c) Vostok I (d) Apollo XI

24. **The setting sun often looks oval in shape because of:**
(a) The fact that sun really becomes oval in the evening
(b) Refraction of rays of sun passing through the atmosphere
(c) Optical illusion (d) Dispersion

25. **Which one of the following is applicable to the planet 'Venus'?**
(a) Smallest (b) Brightest (c) Most dense (d) Largest

26. **Which of the following planets is popularly known as 'Morning Star'?**
(a) Saturn (b) Jupiter (c) Mars (d) Venus

27. **The first astronaut to set foot on moon was:**
(a) Yuri Gagarin (b) Neil Armstrong
(c) Alen Shepherd (d) Edwin Aldrin

28. The position of a planet when it is nearest to the sun is:

(a) **Perihelion** (b) Aphelion (c) Apogee (d) Perigee

29. Name the largest moon in our solar system:

(a) **Ganymede** (b) Titan (c) Callisto (d) Miranda

30. The sun arises on the North pole on the 21st March and this pole remains in light till?

(a) **23rd Sept** (b) 21st Oct (c) 22nd June (d) 22nd Dec

31. The greatest single mass of ice on the Earth is found in:

(a) Canada (b) Siberia (c) **Antarctica** (d) Greenland

32. The mass of the moon in comparison to the Earth is:

(a) 1/4 (b) **1/81** (c) 1/100 (d) None of these

33. Excluding the sun and moon, the celestial objects which appears brightest in the sky is:

(a) **Venus** (b) Jupiter (c) Polestar (d) Cirrus

34. The heaviest mass revolving around the sun is:

(a) Moon (b) **Jupiter** (c) Neptune (d) Pluto

35. The rising of the evening star indicates the:

(a) South pole (b) North pole (c) East (d) **West**

36. Which is the hottest planet in our solar system?

(a) **Venus** (b) Neptune (c) Mars (d) Jupiter

37. Which of the following does not qualify as a planet of our solar system?

(a) Pluto (b) Eris (c) Ceres (d) **All of these**

38. Which planet is known as the evening star?

(a) Saturn (b) **Venus** (c) Jupiter (d) Mars

39. The planet nearest to the Earth is:

(a) Mercury (b) Mars (c) **Venus** (d) Saturn

40. The planet nearest to the Sun is:

(a) Mars (b) **Mercury** (c) Jupiter (d) Saturn

41. On which planet are scientists hopeful of the existence of some type of life?

(a) Venus (b) Saturn (c) **Mars** (d) Jupiter

42. Which of the following planets is a dwarf planet?

(a) Makemake (b) Ceres (c) Pluto (d) **All of these**

43. The time taken by Uranus to revolve round the sun is approximately:

(a) 76 years (b) 80 years (c) **84 years** (d) 90 years

44. Bodies which usually fall from the sky on the Earth are called:

(a) Comets (b) Meteors (c) **Meteoroids** (d) None of these

45. Comets are luminous celestial bodies moving round the:

(a) **Sun** (b) Moon (c) Earth (d) Jupiter

46. **Sun rises in the east and sets in the west due to the:**
(a) Shape of the Earth
(b) Revolution of the Earth around the Sun
(c) **Rotation of the Earth on its axis**
(d) Movement of the Sun

47. **The umbra is:**
(a) **The inner and dark portion of the shadow**
(b) Formed by tangents to the sun and moon
(c) Both (a) and (b)
(d) None of these

48. **Lunar eclipse occurs only on:**
(a) First quarter
(b) **Full moon**
(c) New moon
(d) Last quarter

49. **What are comets made of?**
(a) **Ice and dust**
(b) Rock
(c) Hydrogen
(d) Metal

50. **Solar eclipse occurs on:**
(a) First quarter day
(b) Full moon day
(c) **New moon day**
(d) Last quarter day

CHAPTER 2

GEOGRAPHY

Earth Science is the field of study concerned with the planet Earth. Earth science includes the sciences used to study the lithosphere, the atmosphere, the hydrosphere, the biosphere and space beyond the atmosphere. Usually, it includes geology, meteorology, climatology, oceanography, hydrology, biogeography, zoogeography, astronomy and astrophysics.

Important Facts about Earth	
Equatorial radius	6,378 km
Equatorial inclination	23.5°
Mass	5.97×10^{24} kg
Average density	5.52 g/cm^3
Rotational period	23 hrs, 56 min and 04 sec
Orbital period	1 year
Average distance from the Sun	149.6 million km
Perihelion	147 million km
Aphelion	153 million km
Diameter (at equator) And (at the poles)	12756 km 12712 km
Circumference at equator and at poles	40075 km and 40024 km and
Age of the earth	4.5 billion years
Highest point	Mt Everest (8848 m)
Rotation speed of earth	1670km/h
Revolution speed	107,200km/h
Elements in Earth Crust	O_2 (46.6%) and Si (27.7%)
Largest compound in crust	Silicon dioxide (SiO_2)
Largest metal in crust	Aluminium (8.8%)
Density of core	13g/cm^3
Lowest point at surface	Dead sea
Deepest point at earth	Challenger Deep in Mariana Trench.
Longest day	June 22 North and Dec 22 South
Shortest day	Dec 21 North and June 21 South

- **Geology** is the study of Earth, its rocks, and the changes that have occurred or are occurring in the planet.
- **Meteorology** is the investigation of physical processes in the lower atmosphere where Earth's weather is produced. Meteorology studies changes over short periods.
- **Climatology** is the study of the lower atmosphere over long periods of time and especially of how it gets and loses energy and moisture.
- In **oceanography** students learn about the sea in all its aspects.

- **Hydrology** is the investigation of all aspects of water normally fresh water at or near Earth's surface.

EARTH'S STRUCTURE AND COMPOSITION

A considerable body of inferential knowledge concerning Earth's interior has been amassed by geophysical means, primarily by monitoring patterns of the shock waves transmitted through Earth from earthquakes or from human-made explosions. Such seismic waves change their speed and direction whenever they cross a boundary from one type of material to another. Analysis of these changes, augmented by related data on Earth's magnetism and gravitational attraction, has enabled Earth scientists to develop a model of Earth's internal structure.

The structure of Earth can be defined in two ways: by mechanical properties such as rheology (response of rock to stress), or chemically.

- Mechanically, it can be divided into lithosphere, asthenosphere, mesospheric mantle, outer core, and the inner core.
- Chemically, Earth can be divided into the crust, mantle, outer core, and inner core.

In outward appearance, the earth is a nearly spherical ball with a radius of 6378 kilometres (earth's volumetric mean radius is 6371 km).

Earth's Crust

The outermost layer of the earth is the crust. This comprises the continents and ocean basins. The crust has a variable thickness, being 40-70 km thick in the continents and 5-10 km thick in the ocean basins. The crust is composed mainly of alumino-silicates. Temperatures within the deepest parts of the crust may reach 870°C — hot enough to melt rocks. The crust is made up of three kinds of rocks — igneous, sedimentary and metamorphic. Density of earth's crust is about 2.8 g/cm^3. The three-quarters of the earth's crust is covered with water.

The **Mohorovicic discontinuity**, or "Moho", is the boundary between the crust and the mantle. In geology, the word "discontinuity" is used for a surface at which seismic waves change velocity.

The Mantle

The next layer is the mantle, which is composed mainly of ferro-magnesium silicates. It is about 2900 km deep. Seismologists have discovered that the mantle is subdivided into a number of layers. The upper mantle extends from the Moho to a depth of about 400 km (about 250 mi). The upper mantle is composed of iron and magnesium silicates. Within the upper mantle is a zone called the asthenosphere. The asthenosphere is a zone of weakness.

The zone from about 400 km to about 670 km (about 250 miles to about 420 miles) is known as the transition zone. In the transition zone, the minerals, which make up the upper mantle, undergo a process called phase transition, in which they change in structure and form other atomic arrangements. The mantle below 670 km is called the lower mantle. The lower mantle may consist of magnesium, silicon and iron. Unlike the upper mantle, this region does not change much in composition or phase as it gets deeper. It is denser than the upper mantle due to the increase in pressure.

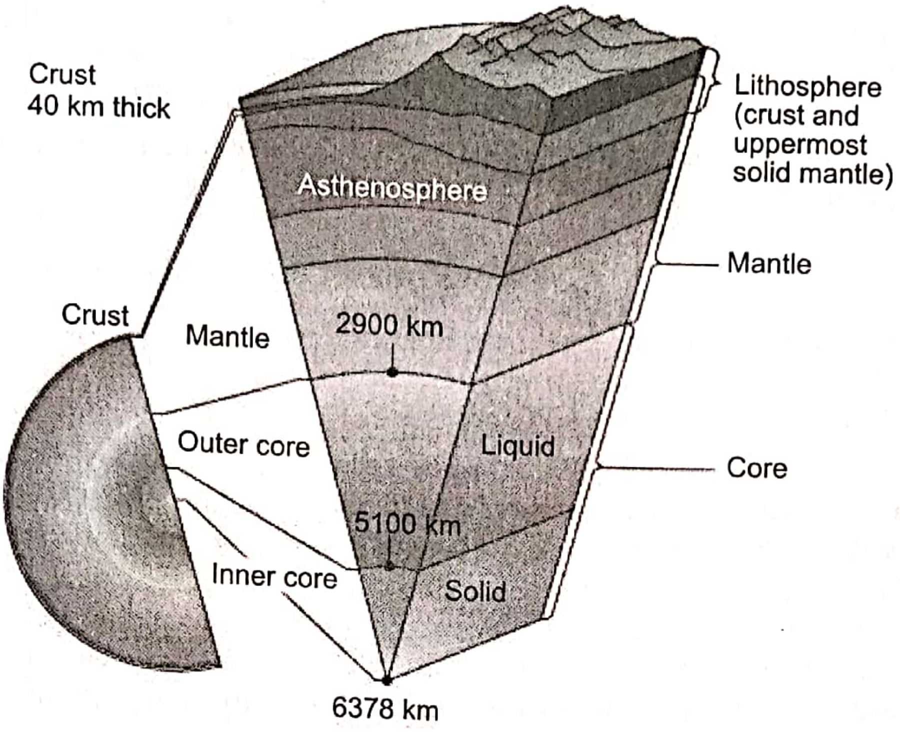


Figure: Earth Structure

Outer Core and Inner Core

The last layer is the core, which is separated into the liquid outer core and the solid inner core. The outer core is 2300 km thick and the inner core is 1200 km thick. The outer core is composed of a nickel-iron alloy, while the inner core is almost entirely composed of iron. Earth's magnetic field is believed to be controlled by the liquid outer core. The pressure at the centre of the earth is extremely high; it is because of this extremely high pressure that the iron in inner core can remain in the solid state despite the very high temperature. .

The earth is separated into two layers based on mechanical properties in addition to composition. The topmost layer is the **Lithosphere**, which comprised the crust and solid portion of the upper mantle.

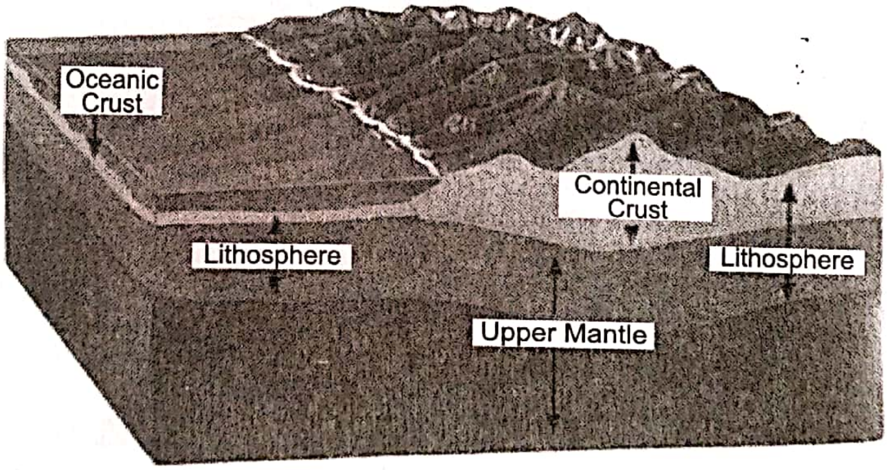


Figure: Lithosphere

The lithosphere essentially floats atop a semi-liquid layer known as the **Asthenosphere.** This layer allows the solid lithosphere to move around since the asthenosphere is much weaker than the lithosphere. Asthenosphere is present 100 km deep under-surface up to 350 km deep.

The **mesosphere** refers to the mantle in the region under the lithosphere and the asthenosphere, but above the outer core.

TECTONIC PLATES

The concept of plate tectonics was formulated in the 1960s. According to the theory, Earth has a rigid outer layer, known as the lithosphere, which is typically about 100 km (60 miles) thick and overlies a plastic layer called the asthenosphere. The lithosphere is broken up into about a dozen large plates and several small ones.

These plates move relative to each other, typically at rates of 1 to 10 cm (0.4 to 4 inches) per year, and interact along their boundaries, where they converge, diverge, or slip past one another. The plates vary considerably in area; some are almost hemispheric in size, whereas others are much smaller. The number of plates and some of their boundaries are not completely clear. Seven major plates, an equal number of intermediate-sized plates, and perhaps a dozen smaller plates, are recognized. Many of the smaller plates are remnants of once larger plates that are now being subducted.

How Do Plates Move?

The mechanism by which tectonic plates move is still a subject of much debate among Earth scientists. The driving mechanism for plate tectonics is thought to be **convection within Earth's mantle.** The Earth is dynamic thanks to its internal heat, which comes from deep within the mantle from the breakdown of radioactive isotopes. This causes convection in the mantle – hot rocks rise and cold rocks descend. This very slow motion in the solid state transfers stresses to the lithosphere, just as convection in a boiling pan of thick soup will cause the skin to buckle where the convection cells meet.

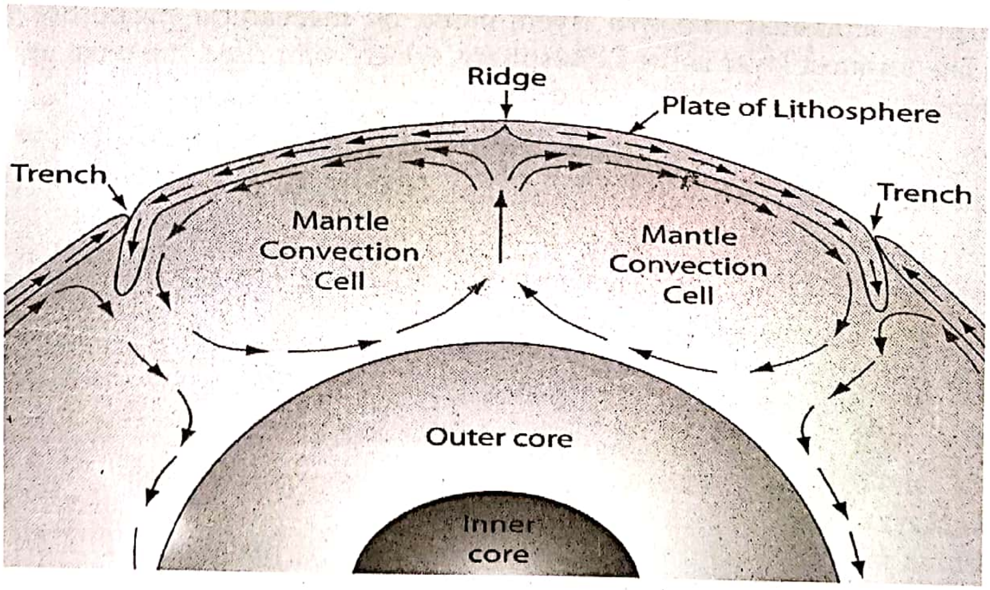


Figure: Mantle Convection Cells

Plate Boundaries

Only three types of contact between plates are possible: two plates may diverge from one another, converge toward one another, or slide laterally past one another.

Divergent Boundaries

At a **divergent boundary** magma from the asthenosphere wells up in the opening between plates. The upward flow of molten material produces a line of volcanic vents that spill out basaltic lava onto the ocean floor, with the plutonic rock gabbro solidifying deeper below. A divergent boundary is usually represented by a ***midocean*** ridge. Most of the midocean ridges of the world are either active or extinct spreading ridges. Such ***spreading centres*** are associated with *shallowfocus earthquakes* (meaning that the ruptures that generate the earthquakes are within about 70 kilometers of the surface), volcanic activity, and hydrothermal metamorphism. Divergent boundaries are said to be "**constructive**" because material is being added to the crustal surface at such locations.

Divergent boundaries can also develop within a continent, resulting in a **continental rift valley** such as the great East African Rift Valley that extends from Ethiopia southward through Mozambique. The Red Sea is also the outcome of spreading taking place within a continent — in this case the spreading has been great enough to form a "proto-ocean."

Convergent Boundaries

At a **convergent boundary**, plates collide and as such are sometimes called "**destructive**" boundaries because they result in removal or compression of the surface crust. Convergent plate boundaries are responsible for some of the most massive and spectacular of earthly landforms: major mountain ranges, volcanoes, and oceanic trenches. There are three types of convergent boundary: *oceanic-continental convergence, oceanic-oceanic convergence*, and *continental-continental convergence.*

1. Oceanic-Continental Convergence

Because oceanic lithosphere includes dense basaltic crust, it is denser than continental lithosphere, and so oceanic lithosphere always underrides continental lithosphere when the two collide. The dense oceanic plate slowly and inexorably sinks into the asthenosphere in the process of **subduction.** The subduction slab pulls on the rest of the plate — such "slab pull" is probably the main cause of most plate movement, pulling the rest of the plate in after itself, as it were. Wherever such an oceanic-continental convergent boundary exists, a mountain range is formed on land (the Andes range of South America is one notable example; the Cascades in northwestern North America is another) and a **parallel oceanic trench** develops as the seafloor is pulled down by the subducting plate.

Earthquakes take place along the margin of a subducting plate. Shallow-focus earthquakes are common at the trench, but as the subducting plate descends into the asthensophere, the earthquakes become progressively deeper, with some subducting zones generating earthquakes as deep as 600 kilometres (375 miles) below the surface.

Volcanoes develop from magma generated in the subduction zone. Early researchers thought that a subducted plated would melt when pushed down into the hot asthenosphere. However, more recent research indicates that such a result in unlikely. Oceanic crust is relatively cold when it approaches a subduction zone and would take a long time to become hot enough to melt. A more likely explanation is that beginning at a depth of about 100 kilometres (about 60 miles) water is driven off from the oceanic crust as it is subducted, and this water lowers the melting point of the mantle rock above, causing it to melt. This magma rises through the overriding plate, producing both extrusive and intrusive igneous rocks. The chain of volcanoes that develops in association with an oceanic-continental plate subduction zone is sometimes referred to as a *continental volcanic arc*.

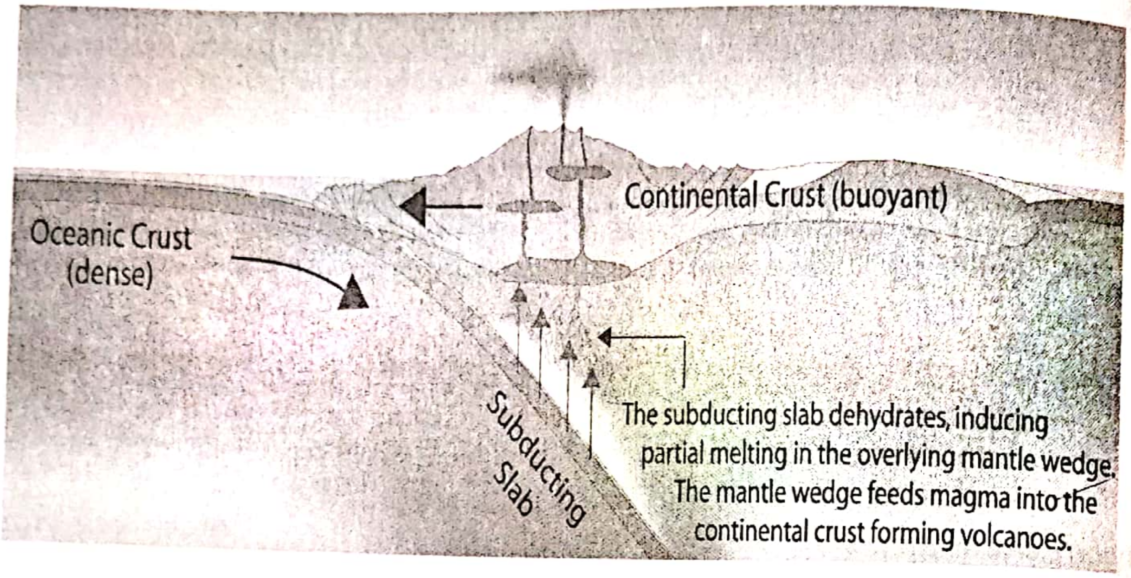

Continental Crust (buoyant)
Oceanic Crust (dense)
Subducting Slab
The subducting slab dehydrates, inducing partial melting in the overlying mantle wedge. The mantle wedge feeds magma into the continental crust forming volcanoes.

Figure: Continental – Oceanic Collision

2. Oceanic-Oceanic Convergence

If the convergent boundary is between two oceanic plates, subduction also takes place. As one of the oceanic plate subducts beneath the other an oceanic trench is formed, shallow sea and deep-focus earthquakes occur, and volcanic activity is initiated with volcanoes forming on the ocean floor. With time, a **volcanic island** arc (such as the Aleutian Islands and Mariana Islands) develops; such an arc may eventually become a more mature island arc system such as Japan and the islands of Sumatra and Java in Indonesia are today.

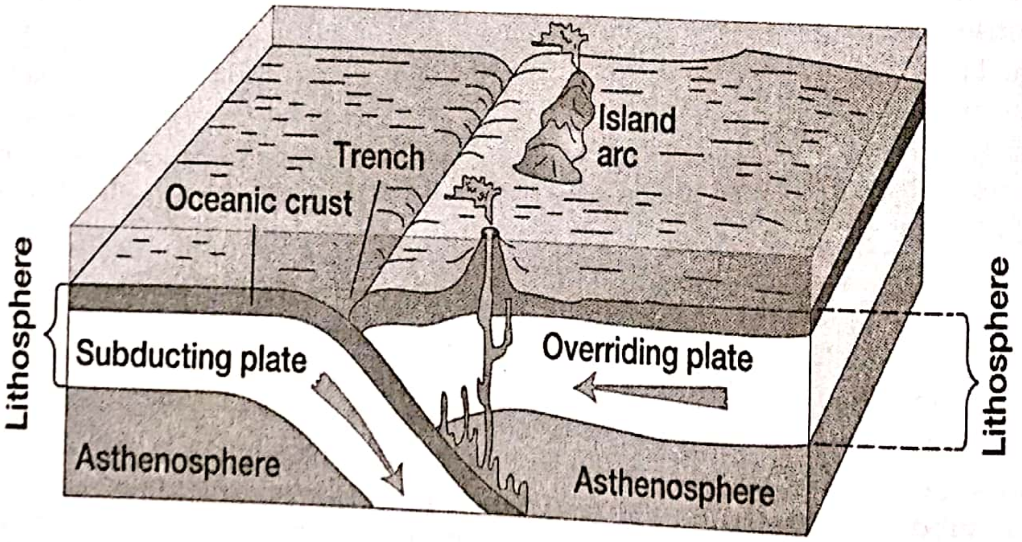


Figure: Oceanic – Oceanic Collision

3. Continental-Continental Convergence

Where there is a convergent boundary between two continental plates no subduction takes place because continental crust is too buoyant to subduct. Instead, huge mountain ranges, such as the Alps, are built up. The most dramatic present-day example of continental collision has resulted in the formation of the Himalayas. The Himalayas began to form more than 45 million years ago, when the subcontinent of India started its collision with the rest of Eurasia. Under the conditions of continental collision, volcanoes are rare, but shallow-focus earthquakes and regional metamorphism are common.

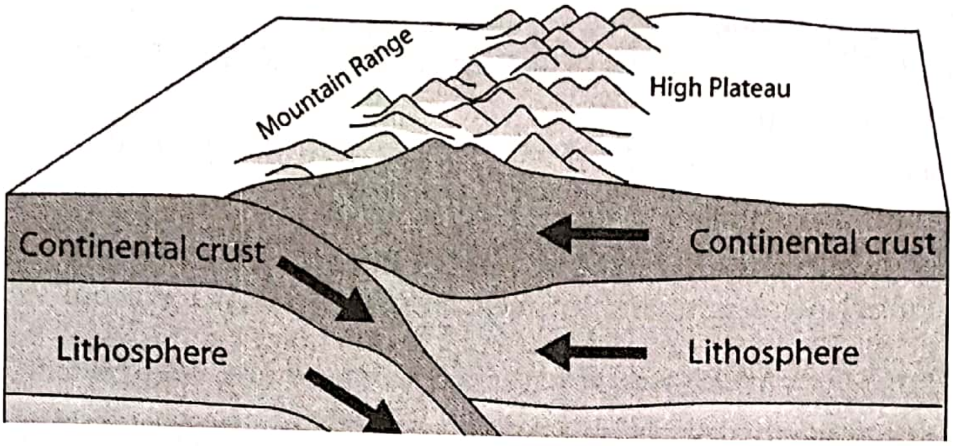


Figure: Continent – Continent Collision

Transform Boundaries

At a **transform boundary**, two plates slip past one another laterally. This slippage occurs along great vertical fractures called *transform faults* (a type of *strike-slip fault*). A transform boundary is classified as **"conservative"** because the plate movements are basically parallel to the boundary, a situation that neither creates new crust nor destroys old. Transform faults are associated with a great deal of seismic activity, commonly producing shallow-focus earthquakes. The most famous fault system in the United States, the San Andreas Fault in California, is on a transform boundary between the Pacific and North American plates.

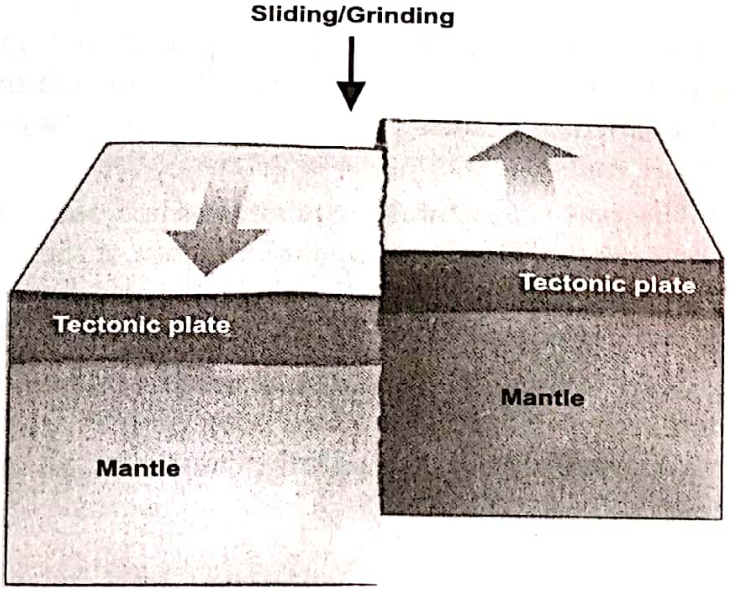


Figure: Transform Boundary

Tectonic plate movement is very important phenomenon to understand earthquakes, volcanoes, formation of mountains and ridges.

MINERALS

Minerals are the building blocks of all rocks. Presently, there are about 4,000 minerals that have been identified. A mineral is defined as a naturally occurring inorganic solid that has a crystal structures and definite chemical composition. To meet the definition of "mineral" used by most geologists a substance must meet five requirements. A mineral:

- is naturally occurring;
- is a solid;
- is inorganic (mostly);
- has a fixed chemical formula;
- has an orderly crystalline structure.

There are eight elements that make up most of these minerals; oxygen, silicon, aluminium, iron, calcium, sodium, potassium, and magnesium; they account for about 98% of the earth's crust.

Properties of Minerals

Minerals have certain physical and chemical properties which are used to identify and describe mineral. These traits include *colour, streak, transparency, lustre, density, hardness, cleavage, fracture, tenacity, and crystal habit.*

Colour: Minerals derive their colour from the presence of a particular element within the crystal lattice. The presence of such an element can determine which wavelengths of light are reflected and which are absorbed.

Streak: Streak is the colour which a mineral displays when it has been ground to a fine powder. Trace amounts of impurities do not tend to affect the streak of a mineral, so this characteristic is usually more predictable than colour. Two different specimens of the same species may be expected to possess the same streak, whereas they may display different colours.

Transparency: Minerals are either opaque or transparent. A thin section of an opaque mineral such as a metal will not transmit light, whereas a thin section of a transparent mineral will. Typically those minerals which possess metallic bonding are opaque whereas those where ionic bonding is prevalent are transparent.

Lustre: Lustre is the property of minerals that indicates how much the surface of a mineral reflects light. The lustre of a mineral is affected by the brilliance of the light used to observe the mineral surface. Lustre thus describes how much the mineral surface 'sparkles'.

Density: The property of density is defined as mass per unit volume. Certain trends exist with respect to density which may sometimes aid in mineral identification. Minerals whose chemical composition contains heavy metals, or atoms possessing an atomic number greater than iron (Fe, atomic number 26), are relatively dense. Dark-colour minerals are typically fairly dense whereas light-colour ones tend to be less dense.

Hardness: Hardness is defined as the level of difficulty with which a smooth surface of a mineral specimen may be scratched. Hardness has historically been measured according to the Moh's scale.

Cleavage and Fracture: Cleavage refers to the splitting of a crystal along a smooth plane. A cleavage plane is a plane of structural weakness along which a mineral is likely to split. **Fracture** takes place when a mineral sample is split in a direction which does not serve as a plane of perfect or distinct cleavage. Some of the minerals have cleavage property and they break or split in a natural pattern while other breaks irregularly, i.e. they have fracture property.

Tenacity: The characteristic of tenacity describes the physical behaviour of a mineral under stress or deformation. Most minerals are brittle; metals, in contrast, are malleable, ductile, and sectile.

Crystal habit: The term crystal habit describes the favoured growth pattern of the crystals of a mineral species. The crystals of particular mineral species sometimes form very distinctive, characteristic shapes.

ROCKS

Rock is any coherent, naturally occurring solid material consisting of one or more minerals. There are three main rock types, i.e. Igneous Rocks, Sedimentary Rocks and Metamorphic Rocks.

Igneous Rocks

Igneous rocks form from the cooling and hardening of magma or lava. Magma is molten rock inside the Earth. Lava is molten rock flowing across Earth's surface. Igneous form of rock has been classified as either **extrusive** or **intrusive**. Intrusive or plutonic rocks are forms of igneous rocks that are formed when the magma solidifies below the Earth crust. Whereas the extrusive or volcanic rocks are formed when the magma comes out on surface in lava form and cools down.

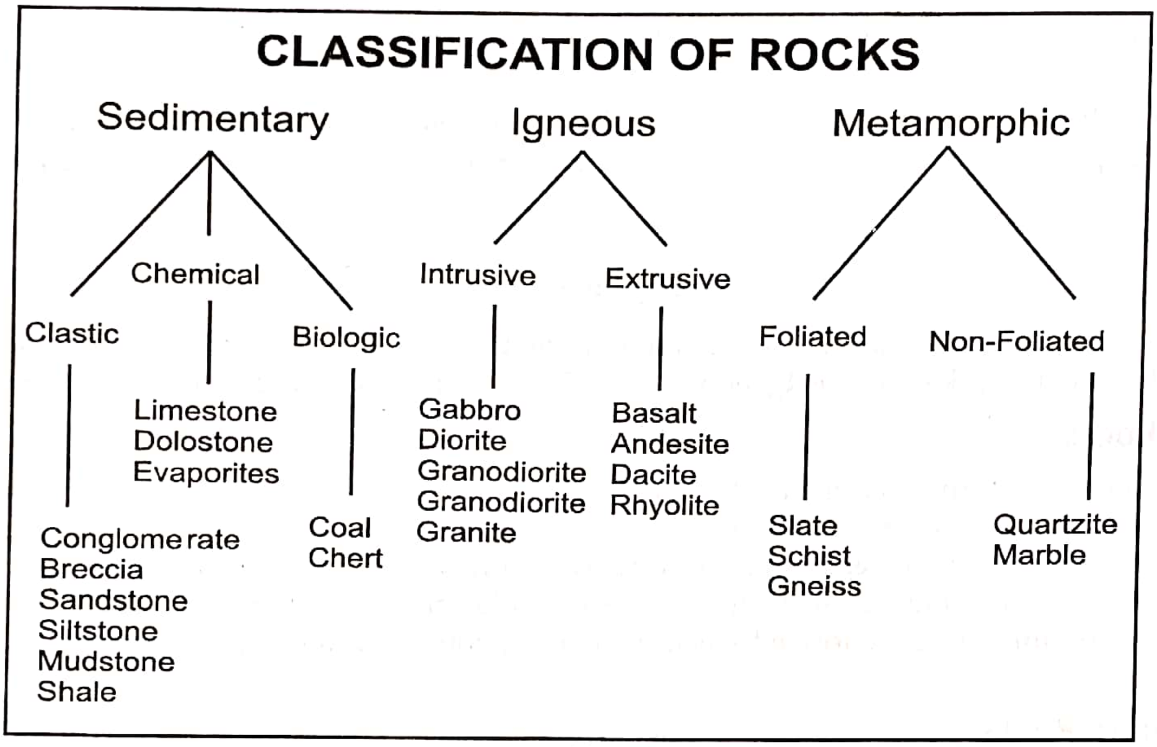
Sedimentary Rocks

Weathering is the process through which rocky materials break down due to physical chemical or biological reasons. Those broken pieces of rock are called sediments. Sedimentary rocks form from sediments that get buried, compacted, and cemented together into a single rock layer. The sedimentary rocks are mainly classified into three different forms. These are organic or biologic sedimentary rocks, clastic sedimentary rocks and chemical sedimentary rocks.

- The **organic or biologic sedimentary** forms mainly comprise of coal and limestones which are formed due to deposition and accumulation of dead plants and animals in rock layers.
- The **chemical sediment** layers are formed when chemical reactions between minerals present in rock forms settle down as precipitate and converts to rock forms over a period of time.
- The **clastic sediments** are formed when rock layers are formed due to mechanical weathering of rock forms.

Metamorphic Rocks

The name of metamorphic rocks is from the Greek word 'Meta' which literally means change and 'morphs' which means form. Metamorphic rocks form when any other rock is exposed to extremely intense heat and pressure. The heat and pressure cause the rock to change into a new form of rock called metamorphic rock. Metamorphic rocks are of two types **Foliated** and **Non-foliated**. Foliated metamorphic rocks such as gneiss, schist, and slate have a layered or banded appearance that is produced by exposure to heat and directed pressure. Non-foliated metamorphic rocks such as marble and quartzite, do not have a layered or banded appearance.



ROCK CYCLE

Rock cycle is the entire journey rocks make as they change. The rock cycle helps to explain how rocks are formed from other rocks. The rock cycle can be defined as time-consuming transitions through geologic time among the three main rock types: sedimentary, metamorphic, and igneous. The cycle is shown in the diagram.

The rock cycle is driven by two forces:

(1) Earth's internal heat which moves material around in the core and the mantle and leads to slow but significant changes within the crust, and

(2) The hydrological cycle, which is the movement of water, ice, and air at the surface, and is powered by the sun.

In describing the rock cycle, we can start anywhere we like, although it's convenient to start with magma. Magma can either cool slowly within the crust (over centuries to millions of years) — forming **intrusive** igneous rock, or erupt onto the surface and cool quickly (within seconds to years) — forming **extrusive** igneous rock. Intrusive igneous rock typically crystallizes at depths of hundreds of metres to tens of kilometres below the surface. To change its position in the rock cycle, intrusive igneous rock has to be uplifted and exposed by the erosion of the overlying rocks.

Through the various plate-tectonics-related processes of mountain building, all types of rocks are uplifted and exposed at the surface. Once exposed, they are weathered, both physically (by mechanical breaking of the rock) and chemically (by weathering of the minerals), and the weathering products — Mostly small rock and mineral fragments — are eroded, transported, and then deposited as **sediments**. Transportation and deposition occur through the action of glaciers, streams, waves, wind, and other agents, and sediments are deposited in rivers, lakes, deserts, and the ocean. Unless they are re-eroded and moved along, sediments will eventually be buried by more sediments. At depths of hundreds of metres or more, they become compressed and cemented into **sedimentary rock.**

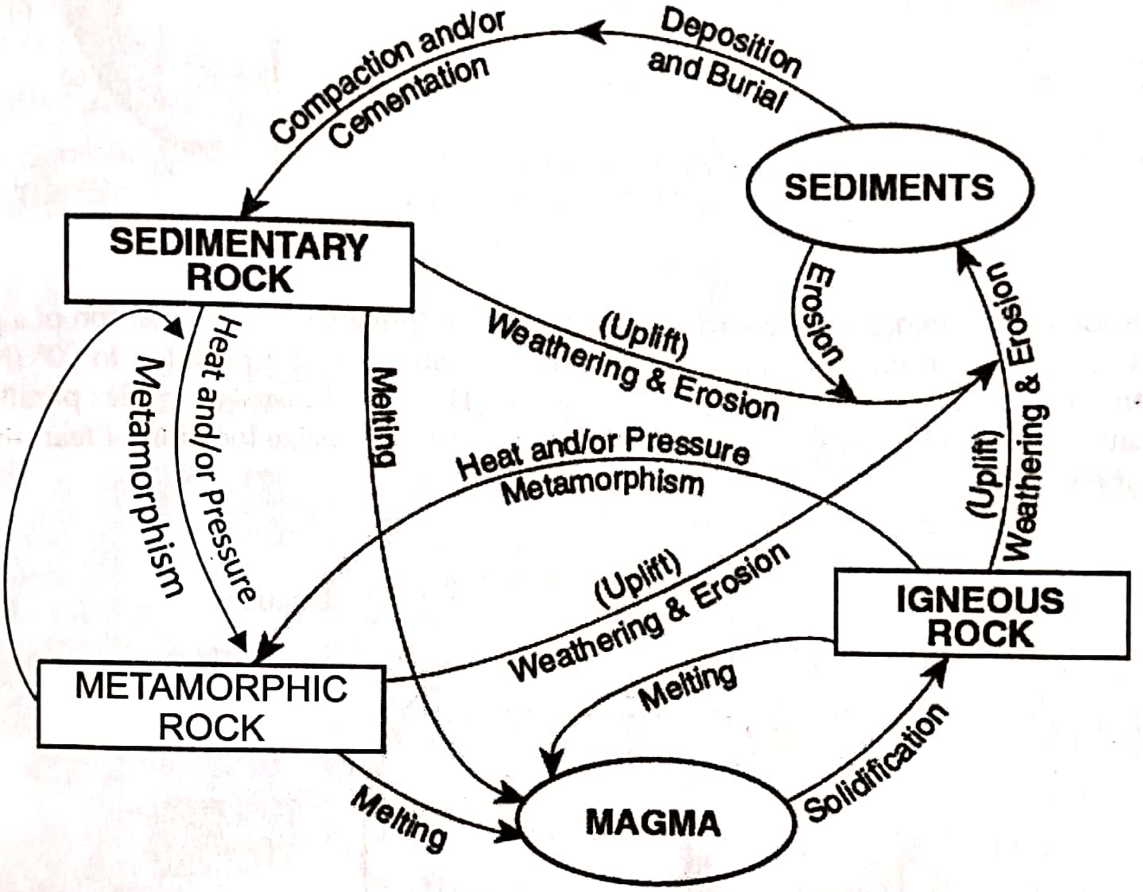
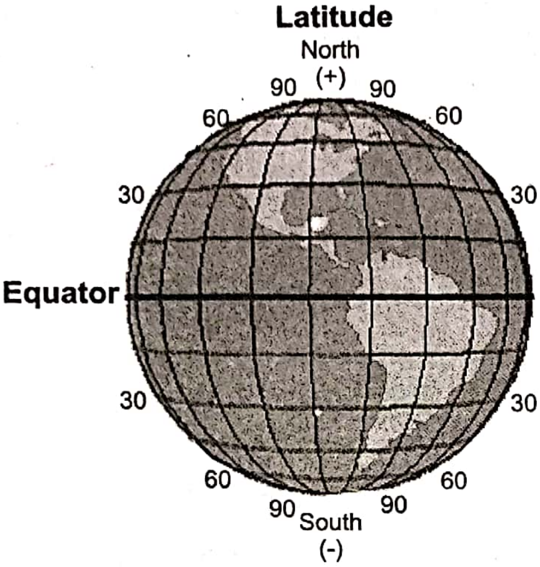


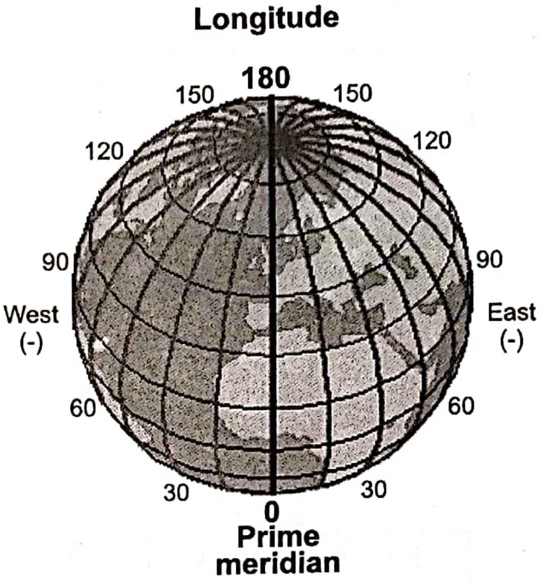
Figure: Rock Cycle

Again through various means, largely resulting from plate-tectonic forces, different kinds of rocks are either uplifted, to be re-eroded, or buried deeper within the crust where they are heated up, squeezed, and changed into **metamorphic rock**. In this way rock cycle goes on and one form of rock is changing to other forms.

LATITUDE AND LONGITUDE

Latitude and Longitude are the units that represent the coordinates at geographic coordinate system. Just like every actual house has its address (which includes the number, the name of the street, city, etc), every single point on the surface of earth can be specified by the latitude and longitude coordinates. Therefore, by using latitude and longitude we can specify virtually any point on earth.





Latitude (φ) is a geographic coordinate that specifies the north–south position of a point on the Earth's surface. Latitude is an angle which ranges from 0° at the **Equator** to 90° (North or South) at the poles. Lines of constant latitude, or **parallels**, run east–west as circles parallel to the equator. Latitude is used together with longitude to specify the precise location of features on the surface of the Earth.

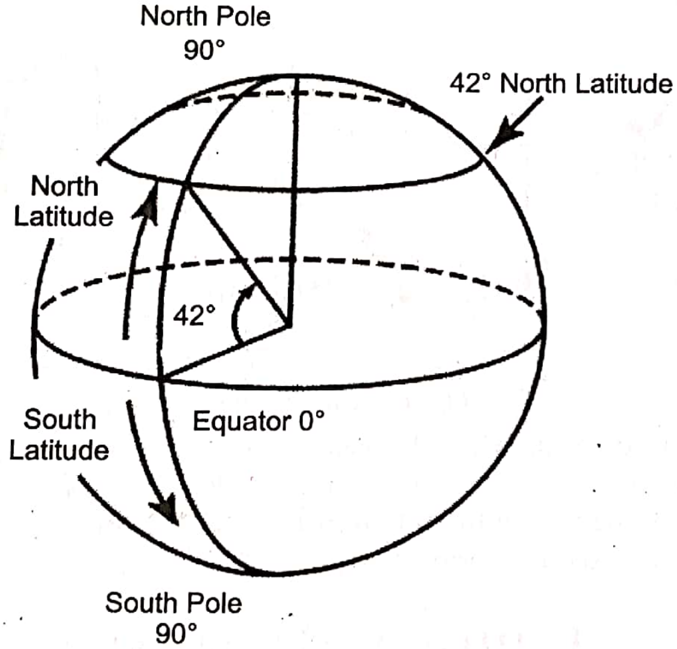


Figure: Equator, North and South Latitude

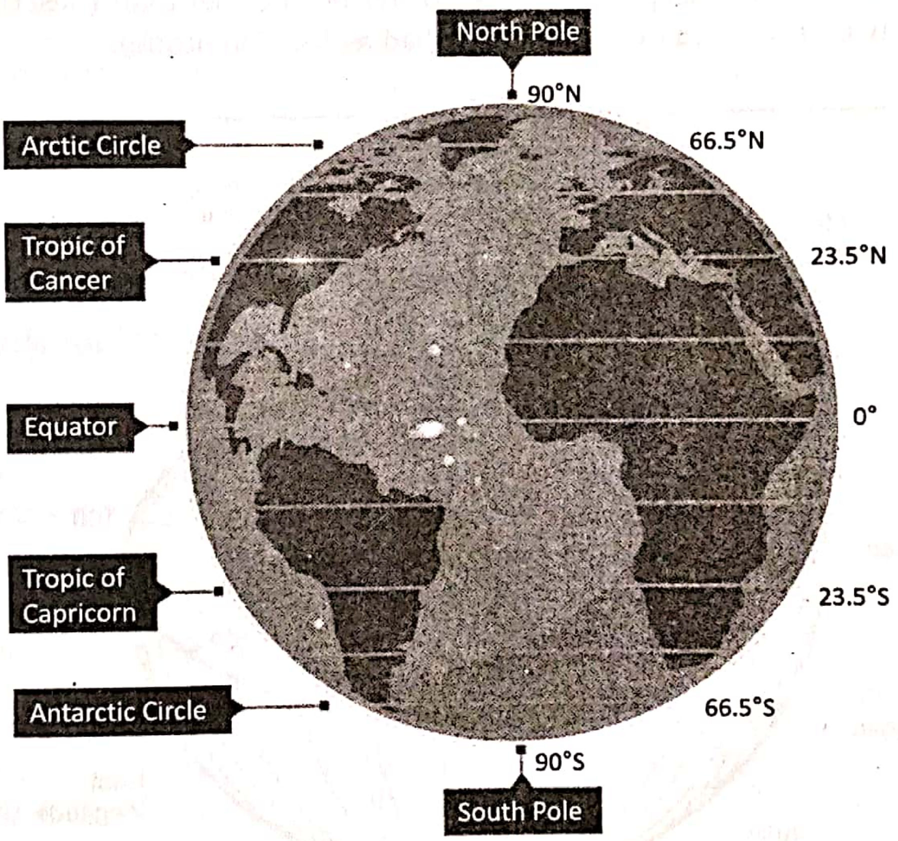
A line connecting all points of the same latitude is called a **parallel** (because it is parallel to all other lines of latitude). The equator is the parallel of 0⁰ latitude, and it, alone of all parallels, constitutes a **great circle**. All other parallels are small circles — all aligned in true east-west directions on Earth's surface. Although it is possible to either construct or visualize an unlimited number of parallels, seven latitudes are of particular significance in a general study of Earth:

1. Equator, 0⁰
2. Tropic of Cancer, 23.5⁰ N
3. Tropic of Capricorn, 23.5⁰ S
4. Arctic Circle, 66.5⁰ N
5. Antarctic Circle, 66.5⁰ S
6. North Pole, 90⁰ N
7. South Pole, 90⁰ S

The North Pole and South Pole are of course points rather than lines, but can be thought of as infinitely small parallels.

Descriptive Zones of Latitude

Regions on Earth are sometimes described as falling within general bands or zones of latitude. The following common terms associated with latitude:



- *Low latitude* — generally between the equator and 30⁰ N and S
- *Mid latitude* — between about 30⁰ and 60⁰ N and S
- *High latitude* — latitude greater than about 60⁰ N and S

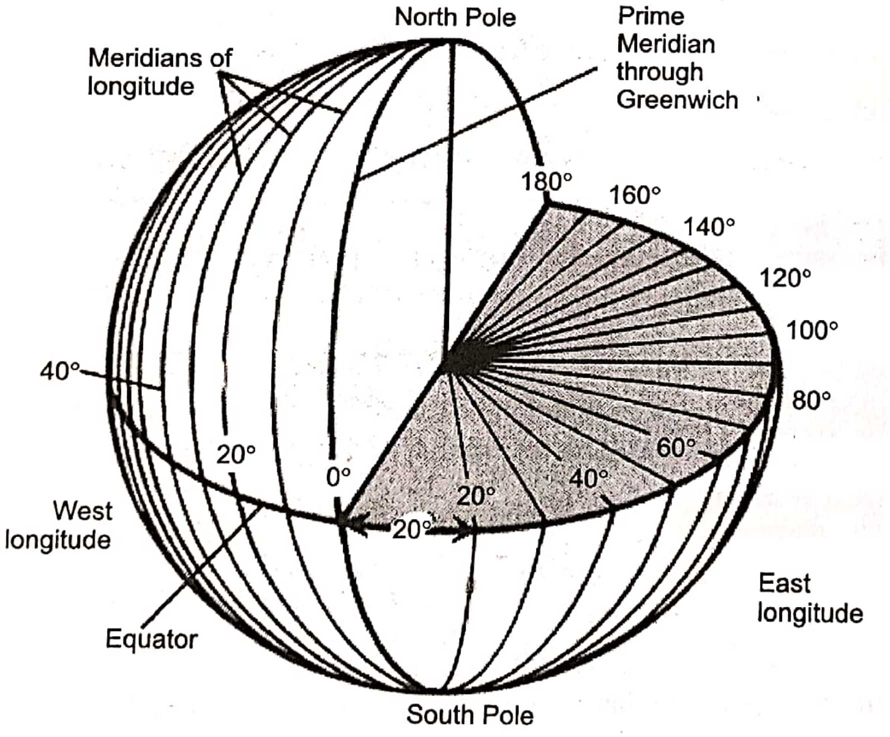
- *Equatorial* — within a few degrees of the equator
- *Tropical* — within the tropics (between 23.5⁰ N and 23.5⁰ *S*)
- *Subtropical* — slightly poleward of the tropics, generally around 25-30⁰ *N* and *S*
- *Polar* — within a few degrees of the North or South Pole

Longitude

Longitude is represented by imaginary lines extending from pole to pole and crossing all parallels at right angles. These lines, called **meridians**, are not parallel to one another except where they cross the equator. Any pair of meridians is farthest apart at the equator, becoming increasingly close together northward and southward and finally converging at the poles.

The distance between any two meridians varies predictably. At the equator, the surface length of one degree of longitude is about the same as that of one degree of latitude. However, because meridians converge at the poles, the distance covered by one degree of longitude decrease poleward, diminishing to zero at the poles where all meridians meet at a point. The Royal Observatory at Greenwich, England, just east of London, is the **prime meridian** for all longitudinal measurement.

Longitude is measured both east and west of the prime meridian to a maximum of 180° in each direction. Exactly halfway around the globe from the prime meridian, in the middle of the Pacific Ocean, is the **180° meridian.** All places on Earth, then have a location that is either east longitude or west longitude, except for points exactly on the meridian (described simply as 0° longitude) or exactly on the 180th meridian (described as 180° longitude).



The network of intersecting parallels and meridians creates a geographic grid over the entire surface of Earth. The location of any place on Earth's surface can be described with great precision by reference to detailed latitude and longitude data.

EARTH-SUN RELATIONS

Life on Earth is dependent on solar energy; therefore, the functional relationship between Earth and the Sun is of vital importance. Because of the perpetual motions of Earth, this relationship does not remain the same throughout the year.

Earth's Rotation on Its Axis

Earth rotates from west to east (counter clockwise) on its axis, a complete **rotation** requiring 24 hours. The Sun, the Moon, and the stars appear to rise in the east and set in the west – this is, of course, an illusion created by the steady eastward spin of Earth.

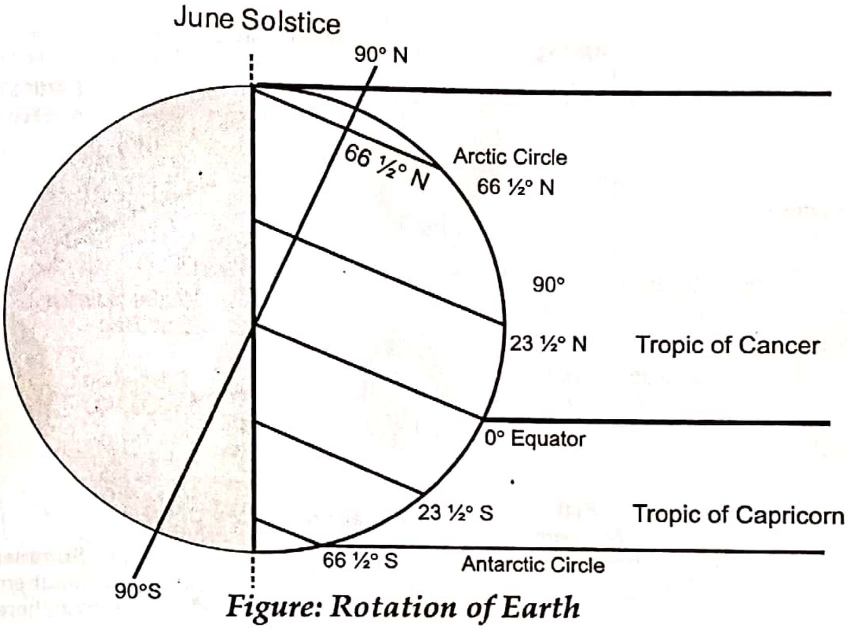


Figure: Rotation of Earth

Rotation causes all of Earth's surface except the poles to move in a circle around Earth's axis. Although the speed of rotation varies by latitude, it is constant at any given place on Earth and so we experience no sense of motion. Rotation has several striking effects on the physical characteristics of Earth's surface. Most important are the following:

1. The constancy of Earth's rotation in the same direction causes an apparent deflection in the flow paths of both wind and ocean currents. The deflection is to the right in the North Hemisphere and to the left in the Southern Hemisphere. This is called **Coriolis Effect.**
2. The rotation of Earth brings any point on the surface through the increasing and then decreasing gravitational pull of the Moon and the Sun. Although the land areas of Earth are too rigid to be significantly moved by these oscillating gravitational attractions, oceanic waters move on shore and then recede in a rhythmic pattern as a result of the interplay of earthly rotation with these gravitational forces. The rise and fall of water level constitutes the **tides.**

3. Undoubtedly the most important effect of earthly rotation is the *diurnal* (daily) alternation of light and darkness, as portions of Earth's surface are turned first toward and then away from the Sun. This variation in exposure to sunlight greatly influences local temperature, humidity, and wind movements.
4. The rotation of earth has created bulge at equator.

Earth's Revolution around the Sun

Another significant Earth motion is its revolution around the Sun. Each revolution takes 365 days, 5 hours, 48 minutes, and 46 seconds. This is officially known as the *tropical year* and for practical purposes is usually simplified to 365.25 days.

The path followed by Earth in its journey around the Sun is not a true circle but an ellipse. Because of this elliptical orbit, the Earth-Sun distance is not constant; rather, it varies from 147,166,480 kilometres (91,455,000 miles) at the closest or **perihelion** position.

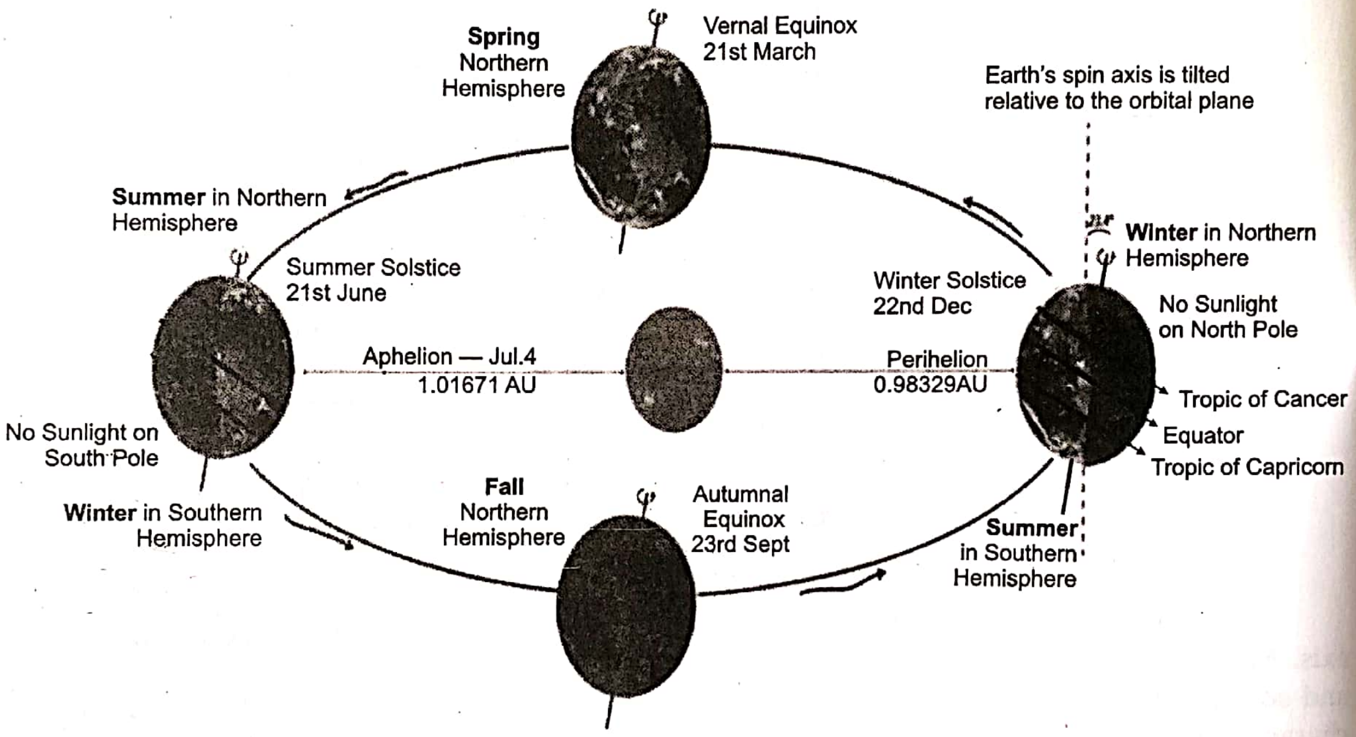


Figure: Revolution of Earth

While the varying distance between Earth and the Sun does not cause the change of seasons, two additional factors in the relationship of Earth to the Sun — inclination and polarity — work together with rotation and revolution to produce the changes of seasons.

Equinox and Solstice

There are only two times of the year when the Earth's axis is tilted neither toward nor away from the sun, resulting in a "nearly" equal amount of daylight and darkness at all latitudes. These events are referred to as **Equinoxes.** The word equinox is derived from two Latin words - aequus (equal) and nox (night). At the equator, the sun is directly overhead at noon on these two equinoxes. Therefore, on the equinox and for several days before and after the equinox, the length of day will be about 12 hours.

A **solstice** is an astronomical event that occurs twice each year (in June and December) as the Sun reaches its highest or lowest excursion relative to the celestial equator on the celestial sphere. The seasons of the year are directly connected to both the solstices and the equinoxes.

The term solstice can also be used in a broader sense, as the day when this occurs. The day of the solstice is either the longest day of the year (summer solstice) or the shortest day of the year (winter solstice) for any place outside of the tropics.

Conditions on Equinoxes and Solstices

	March Equinox	June Solstice	September Equinox	December Solstice
Latitude of Vertical Rays of Sun	0^0	23.5^0 N	0^0	23.5^0 S
Day length at Equator	12 hours	12 hours	12 hours	12 hours
Day length in midlatitudes of Northern Hemisphere	12 hours	Day length becomes longer with increasing latitude north of equator.	12 hours	Day length becomes shorter with increasing latitude north of equator.
Day length in midlatitudes of Southern Hemisphere	12 hours	Day length becomes shorter with increasing latitude south of equator.	12 hours	Day length becomes longer with increasing latitude south of equator.
24 hours of daylight	Nowhere	From Arctic Circle to North Pole	Nowhere	From Antarctic Circle to South Pole
24 hours of darkness	Nowhere	From Antarctic Circle to South Pole	Nowhere	From Antarctic Circle to North Pole
Season in Northern Hemisphere	Spring	Summer	Autumn	Winter
Season in Southern Hemisphere	Autumn	Winter	Spring	Summer

For all regions in the Northern Hemisphere up to the latitude of the Arctic Circle, following the shortest day of the year on the December solstice, the period of daylight gradually increases, reaching 12 hours of daylight on the March equinox. After the equinox, day length continues to increase until the longest day of the year on the June solstice. (During this period, day length is diminishing in the Southern Hemisphere.)

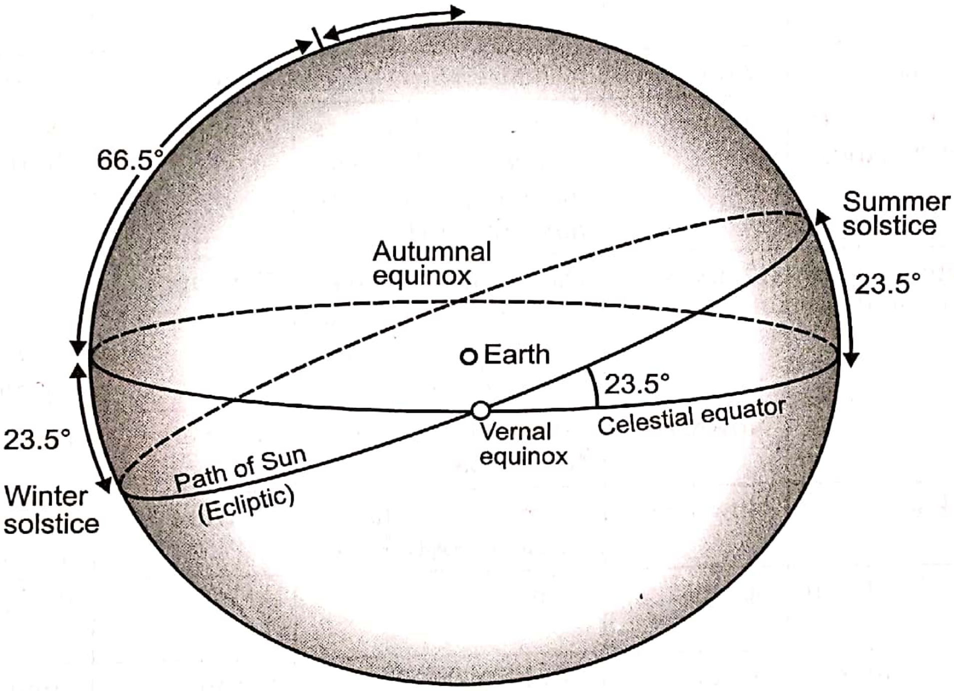
Following the longest day of the year in the Northern Hemisphere on the June solstice, the pattern is reversed, with the days getting shorter in the Northern Hemisphere — reaching 12 hours on the September equinox, and then diminishing until the shortest day of the year on the December solstice. (During this period, day length is increasing in the Southern Hemisphere.)

Day Length in the Arctic and Antarctic

The patterns of day and night in the Arctic and Antarctic deserve special mention. For an observer at the North Pole, the Sun rises on the March equinox and is above the horizon continuously for the next six months — circling the horizon higher and higher each day until the June solstice, after which it circles lower and lower until setting on the September equinox.

Week by week after the March equinox, the region experiencing 24 hours of daylight extends south from the North Pole until the June solstice — when entire region from the North Pole to the Arctic Circle experience 24 hours of daylight. Following the June solstice, the region in the Arctic experiencing 24 hours of daylight diminishes week by week until the September equinox — when the Sun sets at the North Pole and remains below the horizon continuously for the next six months.

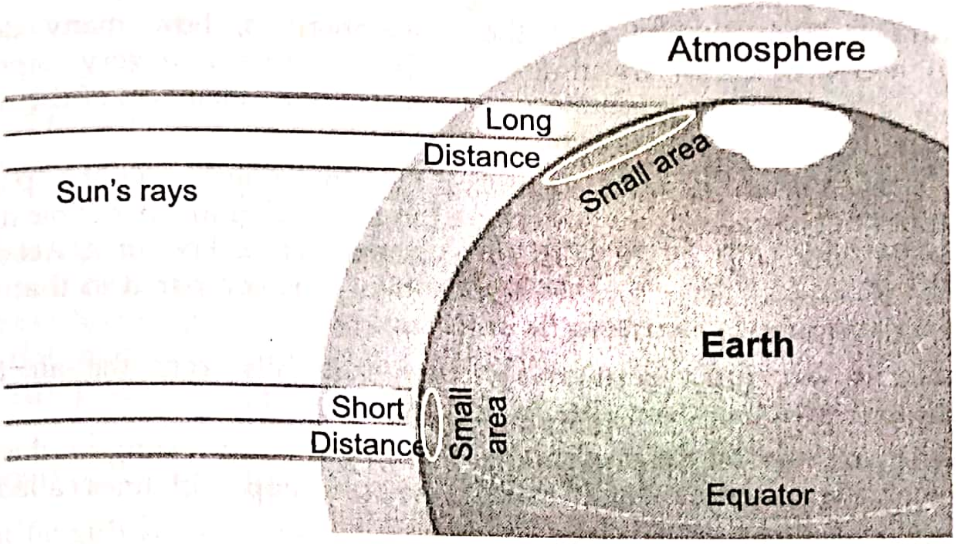
Week by week following the September equinox, the region experiencing 24 hours of darkness extends south from the North Pole until the December solstice — when the entire region from the North Pole to the Arctic Circle experiences 24 hours of darkness. Following the December solstice the region experiencing 24 hours of darkness diminishes week by week until the March equinox — when the sun again rises at the North Pole.



In the Antarctic region of the Southern Hemisphere, these seasonal patterns are simply reversed.

Significance of Seasonal Patterns

Both day length and the angle at which the Sun's rays strike Earth are principal determinants of the amount of solar energy received at any particular latitude. As a generalization, the higher the angle at which the sunlight strikes Earth, the more effective is the resultant heating. Where the vertical rays of the Sun strike Earth, solar energy is concentrated onto the smallest possible surface area. Where the Sun's rays strike Earth at smaller angles, the same amount of energy is spread over a larger surface area — thus, the amount of energy reaching a particular surface area is significantly smaller. Day length influences patterns of solar energy receipt on Earth as well. For example, short periods of daylight in winter and long period of daylight in summer contribute to seasonal differences in temperature in the mid and high latitude regions of Earth.



Difference between Rotation of Earth and Revolution of Earth

Rotation of Earth	Revolution of Earth
Rotation of earth is the spinning at its own axis.	Revolution of earth is the movement of earth around sun.
Earth completes one rotation in one day.	Earth completes one revolution in one year.
Due to rotation days and nights are formed.	Due to revolution seasons are formed.
Earth rotates from west to east.	Earth revolves counter clock-wise.
Rotation speed at equator is almost 1000 mph.	Revolution speed is incredible 66,000 mph.
Rotation is the cause of tides, currents and winds.	Revolution is the cause of equinox and solstice.
Rotation causes bulge at the equator of earth.	Revolution balances centrifugal and centripetal forces of earth.

CLIMATE AND WEATHER

Weather describes the condition of the atmosphere over a short period of time, e.g. from day to day or week to week, while climate describes average conditions over a longer period of time. Humidity, air, temperature, pressure, wind speed, wind direction, cloud cover and type, and the amount and form of precipitation are all atmospheric characteristics of the momentary conditions we call weather.

It has been said that "climate is what you expect; weather is what you get." In other words, you can expect snow in Muree in January, but you may or may not get it on a particular day. The climate of an area or country is known through the average weather over a long period of time. If an area has more dry days throughout the year than wet days, it would be described as a dry climate; a place which has more cold days than hot days would make it known to have a cold climate.

Elements of weather and climate

Following are the elements of weather and climate: Temperature, humidity, pressure, predication, winds and clouds.

Temperature is how hot or cold the atmosphere is, how many degrees **Celsius (centigrade)** it is above or below freezing (0°C). Temperature is a very important factor in determining the weather, because it influences or controls other elements of the weather, such as precipitation, humidity, clouds and atmospheric pressure.

Humidity is the amount of water vapour in the atmosphere. Water vapour results from evaporation or transpiration. Humidity is measured in terms of grams per cubic metres (gm/m^3). The amount of water vapour in a volume of air or atmosphere is known as Absolute Humidity. The amount of water vapour present in the atmosphere (air) compared to that when the air is fully saturated is known as Relative Humidity.

Precipitation is the term given to moisture that falls from the air to the ground. Precipitation includes snow, hail, sleet, drizzle, fog, mist and rain.

Atmospheric pressure (or air pressure) is the weight of air resting on the earth's surface. Pressure is shown on a weather map, often called a synoptic map, with lines called isobars.

Wind is the movement of air masses from high pressure areas (highs) to low pressure areas (lows).

Cloud can be referred as a visible mass of condensed water vapour floating in the atmosphere, typically high above the ground. Condensation or deposition of water above the Earth's surface creates clouds. In general, clouds develop in any air mass that becomes saturated (relative humidity becomes 100%).

Weather Forecasting

The prediction of weather at some future time is based upon an understanding of weather processes and observations of present conditions. Thus, when there is a certain sequence of cloud types, rain usually can be expected to follow. With the establishment of weather observation stations, continuous and accurate weather information became available. As observations expanded and communication techniques improved, knowledge of simultaneous conditions over wider areas became available. This made possible the collection of "synoptic" reports at civilian and military forecast centres. Now, better weather forecasts are available with the use of weather satellites. Weather conditions are televised every-day. When a cyclone or dangerous weather is expected, warnings are issued over the radio, television and newspapers so that people can prepare to save themselves and their property from its hazard.

CLIMATE

Climate is the composite or generally prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years.

Factors affecting climate

Different regions of the world have differences in temperature, humidity and precipitation. These differences influence the lifestyle of the people living under different climatic conditions. To understand different climatic conditions, it is important to understand the factors which cause the variations in the climate of a place or a region.

Latitude or Distance from the Equator: The places near the equator are warmer than the places which are far away from it. This is because the rays of the sun fall vertical on the equator and slanting in the temperate and polar regions. Vertical rays are concentrated over a small area than the slanting one. Pakistan which is near the equator is warmer than England which is far away from the equator.

Altitude or the Height from the mean sea level: We all know that mountains are cooler than the plains. The temperature decreases with the height of a place. For a vertical rise of 165 metres there is an average decrease in temperature at the rate of 1°C. Thus, the temperature of Murree and Quetta is less than Multan and Jacobabad.

Continentality or the Distance from the Sea: The water is a bad conductor of heat, i.e. it takes longer time to heat and longer time to cool. Due to this moderating effect of the sea, places near the coast have low range of temperature and high humidity. The places in the interior of the continent do not experience moderating effect of the sea. These places have extreme temperatures. The places far from the sea have higher range of diurnal (daily) and annual temperatures.

Nature of the Prevailing Winds: The on-shore winds such as Moonsoon bring the moisture from the sea and cause rainfall on the area through which they pass. The off-shore winds coming from the land are dry and help in evaporation.

Cloud Cover: Clouds have profound impact on atmospheric conditions of area. In desert areas cloudless sky observes high temperatures even under shade because of the hot day time sunshine. At night this heat radiates back from the ground very rapidly. It results in a large diurnal range in temperature. On the other hand, under cloudy sky at deserts hinder both incoming and outgoing radiation which decreases the range of temperature.

Ocean Currents: Ocean waters move from one place to another partly as an attempt to equalize temperature and density of water. Ocean currents are large movements of water usually from a place of warm temperature to one of cooler temperature or vice versa. The warm ocean currents raise the temperature of the coast and sometimes bring rainfall, while the cold currents lower the temperature and create fog near the coast. Port Bergen in Norway is free from ice even in winter duc to warm North Atlantic Drift while Port Quebec in Canada remains frozen during winter months due to chilling effect of the Cold Labrador Current in spite of the fact that Port Quebec is situated in much lower latitude than Port Bergen.

Direction of Mountain Chains: The mountain chains act as natural barrier for the wind. The on-shore moisture laden winds are forced to rise after striking against the mountain; and give heavy rainfall on the windward side. These winds descending on the leeward side cause very low rainfall. The great Himalayas check the moisture laden monsoon winds from crossing over to Tibet.

Slope and the Aspect: The concentration of heat being more on the gentler slope raises the temperature of air above them. Its lesser concentration along steeper slopes lowers the temperature. At the same time, mountain slopes facing the sun are warmer than the slopes which are away from the sun's rays. The southern slopes of Himalaya are warmer than the northern slopes.

The Nature of the Soil and Vegetation Cover: The nature of soil depends upon its texture, structure and composition. These qualities vary from soil to soil. Stony or sandy soils are good conductor of heat while black clay soils absorb the heat of the sun's rays quickly. The bare surface reradiates the heat easily. The deserts are hot in the day and cold in the night. The forest areas have lower range of temperature throughout the year in contrast to non-forested areas.

Climate Classification

The Köppen Climate Classification System is the most widely used system for classifying the world's climates. Its categories are based on the annual and monthly averages of temperature and precipitation. The Köppen system recognizes five major climatic types; each one is represented by a capital letter (much like how a variable represents some value in mathematics).

- **A = Tropical Moist.** Very warm climates (no winters) found in the Tropics; all months have average temperatures above 64°F (18°C); and observe high precipitation amounts.
- **B = Dry Desert.** Climates that see little annual precipitation and where evaporation exceeds precipitation.
- **C = Moist Subtropical Mid-Latitude Climates.** Climates having warm-to-hot summers and mild winters; the coldest month has an average temperature between 27°F (-3°C) and 64°F (18°C).
- **D = Mid-latitude Continental.** Climates having warm summers and cold winters; the warmest month has an average temperature above 50°F (10°C); the coldest month has an average temperature below 27°F (-3°C).
- **E = Polar.** Climates that see very cold winters and summers (summer less); the warmest month has an average temperature below 50°F (10°C). Occasionally, you'll hear a 6th climate group mentioned that is highland.
- **H = Highland.** These climates are strongly influenced by altitude.

After establishing the above five major climate groups, Köppen created sub-groups within each based on patterns of temperature and precipitation. We will discuss major climate groups only.

Tropical Moist Climates (A)

Tropical moist climates extend northward and southward from the equator to about 15 to 25° of latitude. In these climates all months have average temperatures greater than 18° Celsius. Annual precipitation is greater than 1500 mm. Three minor Köppen climate types exist in the A group, and their designation is based on seasonal distribution of rainfall.

- **Tropical wet** is a tropical climate where precipitation occurs all year long. Monthly temperature variations in this climate are less than 3° Celsius. Because of intense surface heating and high humidity, cumulus and cumulonimbus clouds form early in the afternoons almost every day. Daily highs are about 32° Celsius, while night time temperatures average 22° Celsius.
- **Tropical monsoon** climate. Annual rainfall is equal to or greater than tropical wet, but most of the precipitation falls in the 7 to 9 hottest months. During the dry season very little rainfall occurs.
- The **tropical wet and dry** or savanna has an extended dry season during winter. Precipitation during the wet season is usually less than 1000 millimeters, and only during the summer season.

Dry Climates (B)

The most obvious climatic feature of this climate is that potential evaporation and transpiration exceed precipitation. These climates extend from 20 - 35° North and South of the equator and in large continental regions of the mid-latitudes often surrounded by mountains. Minor types of this climate include dry arid ad dry semi arid.

Dry arid or desert (BW) is a true desert climate. It covers 12% of the Earth's land surface and is dominated by xerophytic vegetation. These desert climates are found in low-latitude deserts approximately between 18° to 28° in both hemispheres. Winds are light, which allows for the evaporation of moisture in the intense heat. They generally flow downward so the area is seldom penetrated by air masses that produce rain. This makes for a very dry heat.

- **Temperature Range:** 16° C.
- **Annual Precipitation:** 0.25 cm (0.1 in). All months less than 0.25 cm (0.1 in).
- **Global Range:** southwestern United States and northern Mexico; Argentina; North Africa; South Africa; central part of Australia.

Dry semiarid or steppe (BS) is a grassland climate that covers 14% of the Earth's land surface. It receives more precipitation than the dry arid either from the intertropical convergence zone or from mid-latitude cyclones. This dry climate exists in the interior regions of the North American and Eurasian continents. Moist ocean air masses are blocked by mountain ranges to the west and south. These mountain ranges also trap polar air in winter, making winters very cold. Summers are warm to hot.

- **Temperature Range:** 24° C (43° F).
- **Annual Precipitation:** Less than 10 cm (4 in) in the driest regions to 50 cm (20 in) in the moister steppes.
- **Global Range:** Western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior, from steppes of eastern Europe to the Gobi Desert and North China.

Moist Subtropical Mid-latitude Climates (C)

This climate generally has warm and humid summers with mild winters. Its extent is from 30° to 50° of latitude mainly on the eastern and western borders of most continents. During the winter, the main weather feature is the mid-latitude cyclone. Convective thunderstorms dominate summer months. Three minor types exist: humid subtropical, Mediterranean, and marine.

- The **humid subtropical climate** has hot muggy summers and frequent thunderstorms. Winters are mild and precipitation during this season comes from mid-latitude cyclones.
- **Marine climates** are found on the western coasts of continents. They have a humid climate with short dry summer. Heavy precipitation occurs during the mild winters because of the continuous presence of mid-latitude cyclones.
- **Mediterranean climates** receive rain primarily during winter season from the mid-latitude cyclone. Extreme summer aridity is caused by the sinking air of the subtropical highs and may exist for up to five months.

Mid-latitude Continental (D)

Continental mid-latitude climates have warm to cool summers and cold winters. The location of these climates is pole ward of the C climates. The average temperature of the warmest month is greater than 10° Celsius, while the coldest month is less than -3° Celsius. Winters are severe with snowstorms, strong winds, and bitter cold from Continental Polar or Arctic air masses. Like the C climates there are three minor types: **dry winters, dry summers**; and **wet all seasons.**

Polar Climates (E)

Polar climates have year-round cold temperatures with the warmest month less than 10° Celsius. Polar climates are found on the northern coastal areas of North America, Europe, Asia, and on the landmasses of Greenland and Antarctica. Two minor climate types exist.

Polar tundra is a climate where the soil is permanently frozen to depths of hundreds of meters, a condition known as permafrost. Vegetation is dominated by mosses, lichens, dwarf trees and scattered woody shrubs.

Polar ice caps (h) has a surface that is permanently covered with snow and ice.

GEOGRAPHY (MCQS)

Note: Answers are Bold and Underlined.

1. **Earth's crust have the abundant reserves of:**
   (a) **Iron, silicon and oxygen** (b) Silicon, nitrogen and aluminium
   (c) Silicon, oxygen and aluminium (d) Iron, silicon and nitrogen
2. **Atmospheric pressure exerted on earth is due to the:**
   (a) Rotation of earth (b) Revolution of earth
   (c) **Gravitational pull** (d) Uneven heating of earth
3. **Basalt rock is an example of:**
   (a) Metamorphic (b) **Volcanic** (c) Intrusive rock (d) Sedimentary
4. **Which of the following layers makes radio transmission possible?**
   (a) Troposphere (b) **Ionosphere** (c) Mesosphere (d) Stratosphere
5. **The shape of the earth is:**
   (a) Elliptical (b) Oval (c) Spherical
   (d) Oblate spheroid
6. **The equatorial radius of the Earth is approximately:**
   (a) 12,700 km (b) 6,900 km (c) **6371 km** (d) 11,600 km
7. **What is the approximate circumference of the Earth?**
   (a) 25,000 km (b) 16,000 km (c) **40,000 km** (d) 50,000 km

8. **The Earth completes one rotation on its axis in:**
   (a) 23 h 30 min (b) **23 h 56 min 4.9 sec**
   (c) 24 h (d) 23 h 10 min 2 sec
9. **What is the shape of the Earth's orbit around the Sun?**
   (a) Circular (b) Hyperbolic (c) **Ellipse** (d) Parabolic
10. **The polar diameter of the Earth is shorter than its equatorial diameter by:**
    (a) 25 km (b) 80 km (c) **43 km** (d) 30 km
11. **In which part of the atmosphere commercial aircraft usually fly?**
    (a) Thermosphere (b) Stratosphere (c) **Troposphere** (d) Mesosphere
12. **The layer of atmosphere close to the Earth's surface is called:**

(a) Exosphere (b) Ionosphere (c) Stratosphere (d) Troposphere

13. **The Earth is spheroid because of its:**
(a) Revolution around the sum (b) Gravitational force
(c) Centrifugal force of rotation (d) Inclination on its own axis

14. **Earthquakes are caused by:**
(a) Tectonism (b) Denudation
(c) Earth's revolution (d) Earth's rotation

15. **Which of the following is/are the main agent of soil erosion?**
(a) Wind and water (b) Rocks (c) Sand (d) None of these

16. **The most abundant element in the Earth's atmosphere is:**
(a) Argon (b) Nitrogen (c) Oxygen (d) Krypton

17. **The oceans cover approximately _________ of the Earth's surface.**
(a) 50% (b) 60% (c) 70% (d) 80%

18. **The distance between consecutive longitudes at the poles is:**
(a) Zero (b) 18 km (c) 25 km (d) 10 km

19. **Monsoon is caused by:**
(a) Seasonal reversal of winds (b) Revolution of Earth
(c) Movement of clouds (d) Rise in temperature

20. **Equinox means:**
(a) Days are longer than nights (b) Nights are longer than days
(c) Days and nights are equal
(d) The shortest day and longest night in the year

21. **A day is added when a man crosses the International Date Line from:**
(a) North to south (b) East to west (c) West to east (d) South to west

22. **The line joining the areas having the same rainfall is called:**
(a) Isobar (b) Isohyet (c) Isotherm (d) Isohaline

23. **Which of the following is a 'great circle'?**
(a) Arctic Circle (b) Equator
(c) Tropic of Cancer (d) Tropic of Capricorn

24. **Lines drawn parallel to the equator are called:**
(a) Latitudes (b) Longitudes (c) Meridians (d) None of these

25. **Lines joining places of equal temperature are called:**
(a) Isotherms (b) Isohyets (c) Isomers (d) Isobars

26. **Slate, diamond and marble are _________ rocks?**
(a) Igneous (b) Sedimentary (c) Metamorphic (d) None of these

27. **Wind blowing in a spiral form around a region of low atmospheric pressure is a:**

(a) Hurricane (b) Cyclone (c) Anticyclone (d) Tornado

28. On 21st June the sun is vertically overhead the:

(a) Tropic of Capricorn (b) Equator

(c) Position of the sun is not definite (d) Tropic of Cancer

29. For a time difference of one hour the longitudinal distance is equal to:

(a) 15° (b) 30° (c) 45″ (d) 60°

30. The International Date Line passes through:

(a) Exactly through 180° longitude (b) 180° to Equator

(c) Approximately 180° east or west meridian (d) Exactly 0° meridian

31. Which of the following is an igneous rock?

(a) Shale (b) Quartzite (c) Marble (d) Granite

32. Which of the following is an example of sedimentary rock?

(a) Marble (b) Slate (c) Limestone (d) None of these

33. Which of the following pairs is correct?

(a) Marble: Metamorphic rock (b) Basalt: Intrusive igneous rock

(c) Slate: Extrusive igneous rock (d) None of these

34. Savannah Grasslands with tall trees are mainly found in:

(a) South America (b) Africa (c) Central America (d) Australia

35. Pampas are the vast grassy plains of:

(a) South America (b) North America (c) Africa (d) Eurasia

36. Richter scale is used to register intensity of:

(a) Ocean currents (b) Earthquakes

(c) Rotation of the earth (d) Revolution of the earth

37. Bauxite is an important ore of:

(a) Aluminium (b) Zinc (c) Copper (d) Mica

38. Which metal is most abundantly found in the Earth's crust?

(a) Aluminium (b) Zinc (c) Iron (d) Copper

39. The gravitational pull at the lunar surface is______ of Earth.

(a) One-third (b) One-fourth (c) One-fifth (d) One-sixth

40. The Gutenberg discontinuity is between:

(a) The crust and the mantle (b) The upper and lower mantles

(c) The outer core and the lower mantle (d) The inner and outer cores

41. The earth moves from:

(a) West to east (b) East to west

(c) North to south (d) South to north

42. Temperate grasslands of Asia and Europe are called:

(a) Pampas (b) Savannah (c) Steppes (d) Prairie

43. **Sedimentary rocks are:**

(a) Porous (b) Hard (c) Rough (d) Brittle

44. **In the Northern Hemisphere the longest day is on:**

(a) 21st June (b) 21st March (c) 22nd December (d) 21st Sep

45. **The Prime Meridian passes through:**

(a) USA (b) Great Britain (c) Switzerland (d) Finland

46. **As per koppen climate classification category B is:**

(a) Polar (b) Desert (c) Tropical (d) Highland

47. **Arctic circle is located at:**

(a) 23° 27' north of the equator (b) 23° 27' south of the equator

(c) 66° 30' north of the equator (d) 66° 30' south of the equator

48. **Antarctic circle is the parallel of:**

(a) Longitude (b) Latitude (c) Both of these (d) None of these

49. **Latitude measures mean angular distance, expressed in degrees of a point on the Earth's surface:**

(a) North of the equator (b) South of the equator

(c) North or south of the equator (d) East or west of the prime meridian

50. **The zone of the earth that is divided into rigid plates is the ____________:**

(a) Atmosphere (b) Lithosphere (c) Tectosphere (d) Biosphere

51. **In the concept of plate tectonics the term "plates" refers to the ______________:**

(a) Continental crust (b) Crust and the entire mantle

(c) Rigid Earth above the asthenosphere (d) Oceanic crust

52. **The theory of plate tectonics states that rigid "plates" are driven by forces within the Earth and interact by ______________:**

(a) Colliding with each other (b) Pulling apart from each other

(c) Sliding past each other (d) All of these

53. **When two tectonic plates diverge (pull apart) the Earth is thinned. In this scenario, considering the concept of isostasy, we can predict that the asthenosphere will:**

(a) Rise (b) Sink (c) Rise then sink (d) Sink then rise

54. **Weather and climate refer to conditions:**

(a) In the air (b) In the core of the Earth

(c) In empty space (d) Inside a science lab

55. **Which of the following is a characteristic of minerals?**

(a) Inorganic (b) Naturally occurring

(c) Specific chemical composition (d) All of these

CHAPTER 3

ENVIRONMENTAL SCIENCE

> *"The environment is man's first right. Without a safe environment, man cannot exist to claim other rights, be they political, social or economic."*
>
> ***Ken Saro-Wiwa (1941 - 1995)***

The term **environment** has been derived from a French word "Environia" means to surround. The Environment can be broadly defined as one's surroundings. To be more specific we can say that it is the physical and biological habitat that surrounds us. According to P. Gisbert, "Environment is anything immediately surrounding an object and exerting a direct influence on it." The two major classifications of environment are :

- **Physical Environment:** External physical factors like air, water, and land etc. This is also called the abiotic environment.
- **Living Environment:** All living organisms around us, viz. plants, animals, and micro-organisms. This is also called the biotic environment.

Components of Environment

Earth's environment can be further subdivided into the following four segments:

- Atmosphere
- Hydrosphere
- Biosphere
- Lithosphere

ATMOSPHERE

Atmosphere is a gaseous layer surrounding the earth. In other words, we can say that our earth is surrounded by a thin layer of gases, called atmosphere.

Gases in the atmosphere are divided into two kinds, viz. **constant gases** and **variable gases**. Constant gases are the ones whose concentrations do not change over time, and their concentrations almost remain same. Nitrogen and oxygen are the two major constant gases. Nitrogen constitutes 78.09% and oxygen 20.94% by volume thus, making the bulk of the atmosphere. Nitrous oxide and inert gases such as, argon, helium, krypton, and xenon constitute 0.94% by volume. Variable gases are those gases whose concentrations change from time to time and from place to place. Carbon dioxide (0.03%), water vapour and ozone are the variable gases.

The atmosphere blankets Earth, keeping temperatures stable and protecting living organisms from harmful solar radiation. This protective combination of gases extends hundreds of kilometres, from the planet's surface to outer space. In general, the density of atmospheric gases decreases as altitude increases. Atmospheric pressure follows a similar pattern, decreasing with distance from Earth's surface.

In contrast, air temperature follows a less consistent pattern, sometimes falling, sometimes rising with altitude, depending on where in the atmosphere you measure it. Scientists have used this zigzag temperature pattern to define five distinct atmospheric layers. They have also identified the variations in chemical composition that correlate with atmospheric temperature.

The names of the layers in order starting from the lowest layer are: troposphere, stratosphere, mesosphere, thermosphere, and exosphere. All of the names have the suffix "sphere." This is because each layer surrounds the earth.

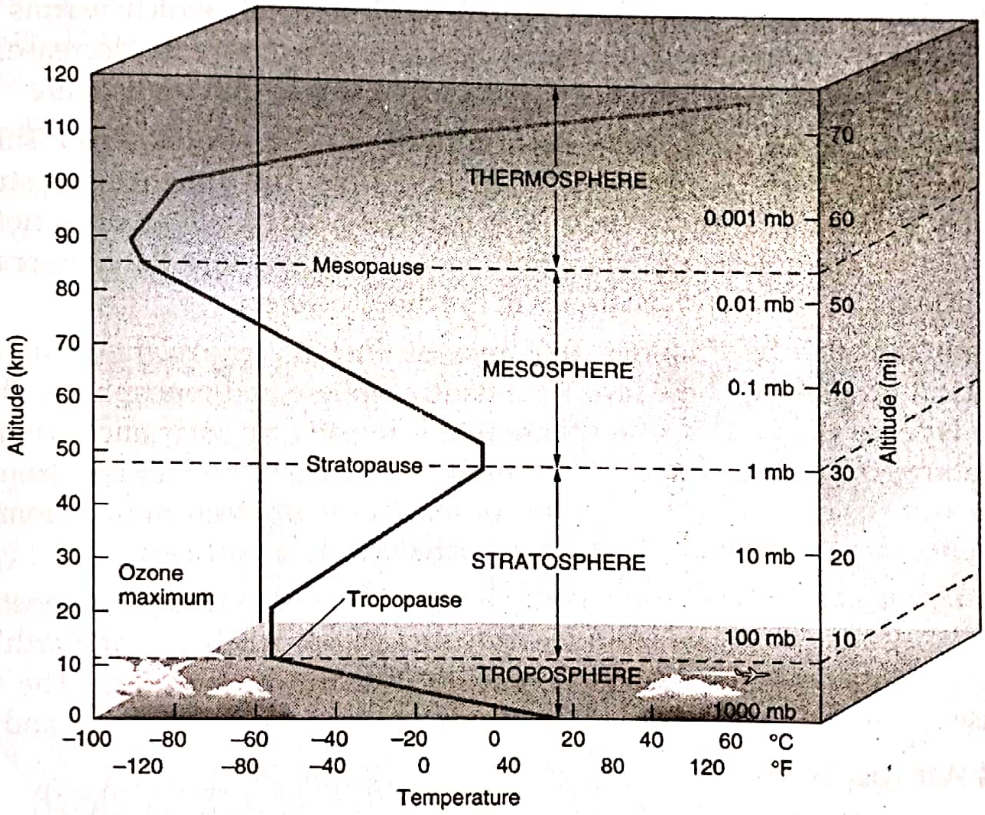


Figure: Layers of Atmosphere

Troposphere: starts at earth's surface and goes up about 12 km. We live in this layer, and this is where weather happens (clouds, precipitation, etc.); and most commercial aircraft fly in this layer. The temperature and air pressure both decrease as you go higher into the troposphere. The temperature decreases up to -53°C.

Stratosphere: starts at about 12 km and goes to about 50 km high. This layer contains the **ozone layer** which protects us from harmful **ultraviolet radiation.** Ultraviolet radiation is an extreme form of heat energy. It can damage living beings and raise earth's temperature severely. Temperature increases as you go higher into the stratosphere. In this layer temperature increase and comes to -03°C.

Mesosphere: This is the middle layer of the atmosphere. It starts at about 50 km and goes up to about 80 km high. Most meteors burn up in this layer, and it is the coldest layer of the atmosphere. The temperatures decrease as you go higher in this layer. The temperature decreases up to – 93ºC as it is the coldest layer.

Thermosphere: This layer is named for its temperature. This is the hottest layer of the atmosphere. It is where auroras are formed because of the ionosphere's charged particles. The temperature increases with height and rises up to 2000ºC or higher.

Exosphere: this is the outermost part of the atmosphere. Temperatures are very high, but can change depending on location. This is where satellites travel. This layer blends into outer space.

Temperature variations in the five layers are due to the way solar energy is absorbed as it moves downward through the atmosphere. The Earth's surface is the primary absorber of solar energy. Some of this energy is reradiated by the Earth as heat, which warms the overlying troposphere. The global average temperature in the troposphere rapidly decreases with altitude until the tropopause, the boundary between the troposphere and the stratosphere.

The temperature begins to increase with altitude in the stratosphere. This warming is caused by ozone (O_3) absorbing ultraviolet radiation from the sun. At the stratopause, the temperature stops increasing with altitude. The overlying mesosphere does not absorb solar radiation, so the temperature decreases with altitude, at the mesopause the temperature begins to increase with altitude, and this trend continues in the thermosphere.

Atmosphere can also be classified into two distinct layers on the basis of a different criteria, i.e. electrical properties. These layers are neutral sphere and ionosphere. The **ionosphere** is defined as the layer of the Earth's atmosphere that is ionized by solar and cosmic radiation. It lies 60-1000 km above the Earth. Because of the high energy from the Sun and from cosmic rays, the atoms in this area have been stripped of one or more of their electrons, or "ionized," and are therefore positively charged. The ionized electrons behave as free particles.

The Sun's upper atmosphere, the corona, is very hot and produces a constant stream of plasma, UV and X-rays that flow out from the Sun and affect, or ionize, the Earth's ionosphere. Only half the Earth's ionosphere is being ionized by the Sun at any time. The ionosphere is important because it reflects and modifies radio waves used for communication and navigation

Importance of Atmosphere

Atmosphere is very important to sustain life on earth. It contains life supporting oxygen in sufficiently large quantities. Constant concentration of oxygen is maintained through oxygen cycle. Atmosphere is the transparent layer through which life sustaining solar radiation passes and reaches the earth's surface or into the water. Solar radiation is the only source to supply energy for photosynthesis to take place on earth, which thereby supports all other life. Ozonelayer prevents about 95% of harmful ultraviolet radiation from reaching the earth's surface.

Heated earth emits the energy in the form of infrared radiation and this radiation is absorbed by carbon dioxide, water and few other gases. This process results in "green house effect". Earth is not heated by solar radiation uniformly due to its inclination. As a result, different weather patterns exist over the earth. In order to compensate these differences, air sets in motion resulting in winds and circulation of air.

These wind currents are of global scale as well as of local scale. They are responsible for disastrous storms like cyclones, dust storms, tornadoes, etc. These wind currents also influence water currents in the oceans; they in turn affect the wind currents. Consequently, understanding the atmosphere and its functions and behaviour is quite complex. Thus, understanding of the atmosphere has become very essential and important. All the above processes make the atmosphere a dynamic atmosphere.

HYDROSPHERE

Hydrosphere is the total amount of water on a planet. The hydrosphere includes water that is on the surface of the planet, underground, and in the air. A planet's hydrosphere can be liquid, vapour, or ice. On Earth, liquid water exists on the surface in the form of oceans, lakes and rivers. It also exists below ground—as groundwater, in wells and aquifers. Water vapour is most visible as clouds and fog. The frozen part of Earth's hydrosphere is made of ice: glaciers, ice caps and icebergs. The frozen part of the hydrosphere has its own name, the **cryosphere.**

Global Water Distribution

An 'inventory' of Earth's waters shows that approximately 97% of the global water supply is found in the oceans, which are saline. A very small amount of salty water is also located in saline lakes (e.g. the Caspian Sea). The remaining water inventory (3%) is fresh water.

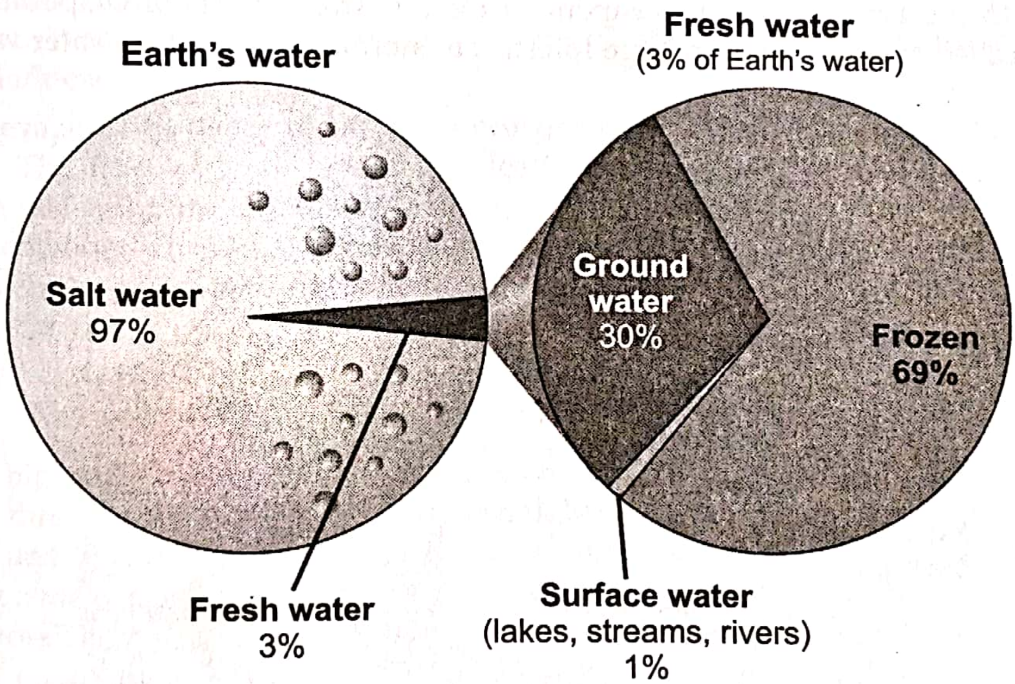


Figure: Global Water Distribution

Permanent ice (e.g. continental and mountain glaciers) is the largest freshwater storage on earth, nearly 69% of the total freshwater supply. Freshwater is also found beneath the earth's surface as groundwater (approximately 30% of the total freshwater supply) only one percent is found in surface water storages such as lakes, streams, swamps and marshes. Minute amounts of freshwater are also stored in the soil, the atmosphere and in biological organisms.

WATER CYCLE

Water moves through the hydrosphere in a cycle. Water collects in clouds, then falls to Earth in the form of rain or snow. This water collects in rivers, lakes and oceans. Then it evaporates into the atmosphere to start the cycle all over again. This is called the **water cycle** or **Hydrologic cycle.**

A fundamental characteristic of the hydrologic cycle is that it has no beginning and it has no end. The hydrologic cycle is used to model the storage and movement of water between the biosphere, atmosphere, lithosphere and hydrosphere. Water is stored in the following reservoirs: atmosphere, oceans, lakes, rivers, glaciers, soils, snowfields, and groundwater. It moves from one reservoir to another by processes like: *evaporation, condensation, precipitation, runoff, infiltration and transpiration.*

Evaporation: Evaporation is the process where a liquid, in this case water, changes from its liquid state to a gaseous state. Liquid water becomes water vapour. Although lower air pressure helps promote evaporation, temperature is the primary factor. During the water cycle some of the water in the oceans and freshwater bodies, such as lakes and rivers, is warmed by the sun and evaporates.

Transpiration: As plants absorb water from the soil, the water moves from the roots through the stems to the leaves. Once the water reaches the leaves, some of it evaporates from the leaves, adding to the amount of water vapour in the air. This process of evaporation through plant leaves is called transpiration. In large forests, an enormous amount of water will transpire through leaves.

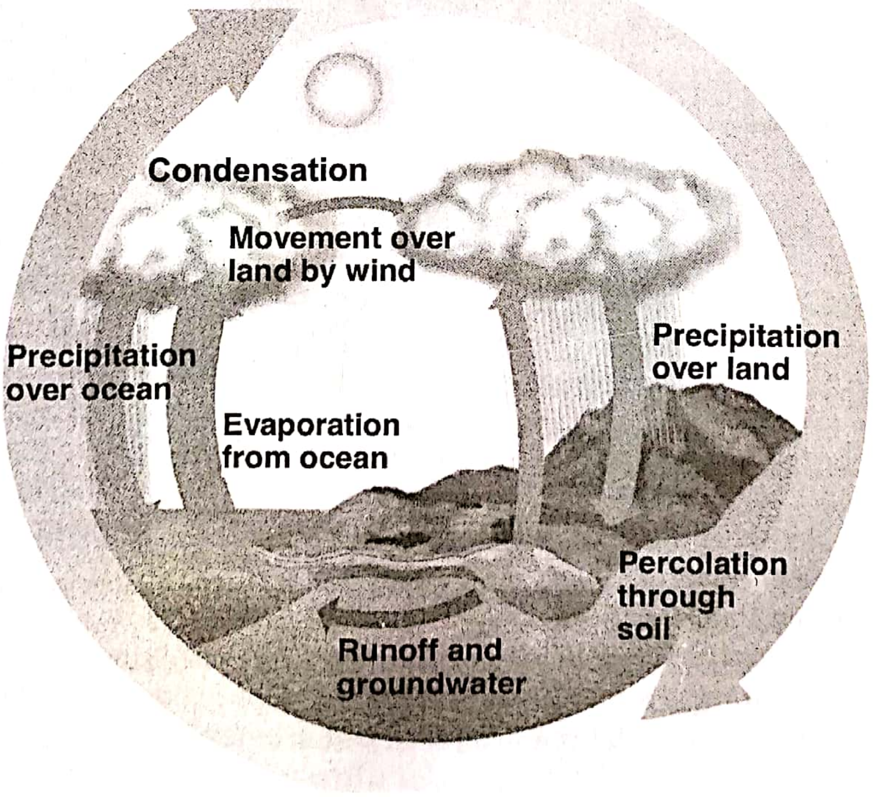


Figure: Water Cycle

Condensation: Condensation is the opposite of evaporation. Condensation occurs when a gas is changed into a liquid. Condensation occurs when the temperature of the vapour decreases. When the water droplets formed from condensation are very small, they remain suspended in the atmosphere. These millions of droplets of suspended water form clouds in the sky or fog at ground level.

Precipitation: Precipitation is the process that occurs when any and all forms (including rain, snow, sleet and hail) of water particles fall from the atmosphere and reach the ground.

Surface Runoff: Much of the water that returns to Earth as precipitation runs off the surface of the land, and flows downhill into streams, rivers, ponds and lakes. Small streams flow into larger streams, then into rivers, and eventually the water flows into the ocean. Surface runoff is an important part of the water cycle because, through surface runoff, much of the water returns again to the oceans, where a great deal of evaporation occurs.

Infiltration: Infiltration is an important process where rain water soaks into the ground, through the soil and underlying rock layers. Some of this water ultimately returns to the surface at springs or in low spots downhill. Some of the water remains underground and is called groundwater.

Importance of Water Cycle

The water cycle involves the exchange of energy, which leads to temperature changes. For instance, when water evaporates, it takes up energy from its surroundings and cools the environment. When it condenses, it releases energy and warms the environment. These heat exchanges influence climate.

The evaporative phase of the cycle purifies water which then replenishes the land with freshwater. The flow of liquid water and ice transports minerals across the globe. It is also involved in reshaping the geological features of the Earth, through processes including erosion and sedimentation. The water cycle is also essential for the maintenance of most life and ecosystems on the planet. The water cycle provides water for our population, animals and plants. It also provides fish to eat.

BIOSPHERE

The biosphere, (from Greek *bios* = life, *sphaira*, sphere) is the *sphere* where life exists. It consists of three components lithosphere (land), hydrosphere (water) and atmosphere (air). Life originated and evolved because of this unique combination of the three components. The life supporting zone of the earth where atmosphere, hydrosphere and lithosphere meet, interact and make life possible, is known as **biosphere.**

This layer ranges from heights of up to 10 km above sea level, to depths of the ocean at more than 8 km/deep. These are the extremes; however, in general the layer of the Earth containing life is thin: the upper atmosphere has little oxygen and very low temperatures, while ocean depths greater than 1000 m are dark and cold. In fact, it has been said that the biosphere is like the peel in relation to the size of an apple. The biosphere is the biggest biological system. It consists of smaller functional units known as biomes.

World Biomes

A biome is a large geographical area of distinctive plant and animal groups, which are adapted to that particular environment. The climate and geography of a region determines what type of biome can exist in that region. Major biomes include deserts, forests, grasslands, tundra, and several types of aquatic environments.

Forest Biome

Forests makeup about 30% of the total land cover on earth and are of incredible value to life on earth. They are a store of carbon and play a very important role in climate control. They have a watershed role and are a source of many raw materials that humans depend on. It is believed that forests have the most biodiversity. A small portion of the rainforests, for example, may be home to millions of insects, birds, animals and plants. There are three main biomes that make up forest biomes. These are the **Tropical Rainforest, Temperate and Boreal Forests** (also called the Taiga).

Temperatures of forests biomes (especially the tropical rainforest) are generally high all year though, but a lot cooler at the surface. This is because there is very little sunlight reaching the forest floors as a result of the heavy vegetative cover. Humidity is extremely high with lots of rainfall, exceeding 200 cm, all year though. Soils are loose and very airy, with high acidity and decaying organic matter.

Plant types of the Tropical Rainforests are usually huge trees with buttress roots, lots of large green leaves and shallow roots. Ferns and palms are also common. Plants in the temperate forests are less dense with a bit of sunlight reaching the floors. Tree types include the willow, basswood and elm. Plants of the Boreal are mostly conifers with needle-like leaves. There is very little understory and lots of light at the floors. Trees like fir and spruce are common.

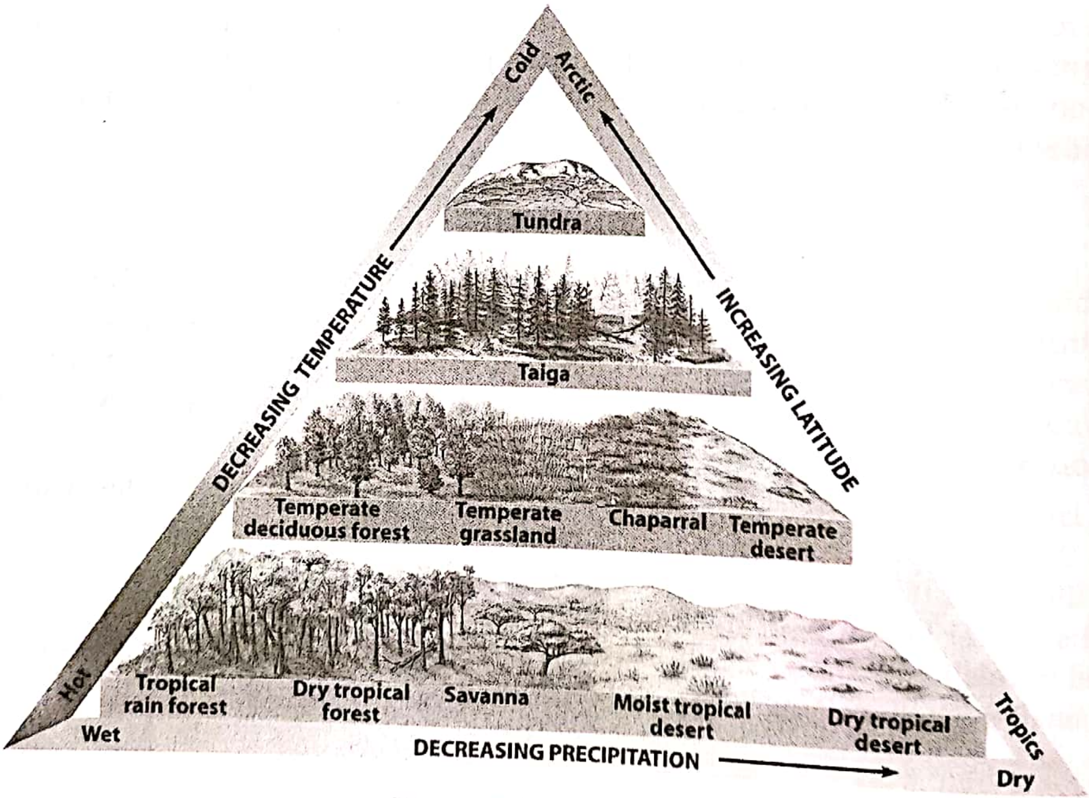


Figure: World Biomes

Small mammals, birds, insects and bats are common in the tropical rainforests, as they either can fly up for sunlight or do not need sunlight. However, all the forest biomes have lots of skunks, deer, squirrels, foxes, birds and reptiles.

An example of the Tropical Rainforest is the Amazon. Other examples are the Scandinavian forest (boreal) and those in the North East of America.

Desert Biome

Deserts makeup about 20% of total land cover on earth and are characterized by little (less than 50 cm/year) or no rainfall. Desert biomes come in four major kinds — each of these having their unique features but have similarities in their biotic and abiotic makeup. They are the **Hot and Dry Deserts, Semiarid Deserts, Coastal Deserts and Cold Deserts**, and within these are many deserts located in many places of the world.

Desert biomes have very high temperatures because of the little vegetative cover, less cloud cover, low atmospheric moisture and the land's exposure to the sun. Humidity is very low, with a few events of very little rain in a year. Soil cover is shallow and rocky, as a result of very little weathering (breakdown) and supports only a few plant types. Soils have very little or no organic matter, and very low in salt content.

Plants that survive here are short shrubs and cacti, which have the ability to conserve water. Plants are also less leafy, using their stems for photosynthesis. Examples of plants are the Karir, Kikar and babul.

Animals here tend to burrow, or stay in hideaways till dusk to avoid the heat. They are mainly small carnivores, birds, insects, snakes and lizards, and are adapted to survive with very little water. Examples of the Hot and Dry Desert biomes include the Sahara of North Africa and the Tharparkar of Pakistan. Semiarid Desert biomes include the sagebrush of Utah, Montana and Great Basin. Atacama Desert of Chile and Peru are examples of Coastal Desert biomes.

Grassland Biome

As the name suggests, these are massive areas dominated by one or a few species of grass, with a few sparsely distributed trees. There are two main types of grassland biomes: the **Savanna Grasslands and the Temperate Grasslands**. One major savanna is located in Africa and takes up more than a third of the continent's land area. Others can be found in India, South America and Australia. Temperate grasslands can be found in South Africa, Argentina, and some plains in Central North America.

Soils in savanna are thin-layered and do not hold water. The soils contain some organic matter from dead grass, which is the main source of nutrients for plants. Rainfall is moderate, and not enough to cause major floods. Animals in the savannas include large mammals such as lions, hyenas, snakes, giraffes and buffaloes with lots of insects. Temperatures in the temperate grasslands are extreme, with high summer and freezing winter temperatures. Animals here include hawks, owls, deer, mice, foxes, rabbits and spiders. Temperate grasslands with short grasses are called **'steppes'** and those with tall grasses are called **'prairies'**.

Tundra Biome

This is known to be the coldest of all the terrestrial (land) biomes, with the least bio-diversity capacity. Tundra got its name from *'Tunturia'* a Finnish word that means 'barren land'.

This biome has very little rain with freezing temperatures, and covers about a fifth of the earth's land surface.

There are two major tundra biomes: The **Arctic Tundra** and the **Alpine Tundra**. The Arctic tundra is located around the North Pole in the Northern hemisphere. This biome has temperatures of about 2 to -3° C in the summer and about -35° C in the winter. Bogs and ponds are common as a result of constantly frozen surface moisture and melted permafrost.

Plants in the Arctic Tundra are short and grow closely to each other. Examples include mosses, heaths and lichen. They are adapted to perform photosynthesis even in the freezing conditions. Animals here include herbivores like hares and squirrels. Carnivores include polar bears and arctic foxes. It also has lots of birds, insets and fish like cod and salmon. The Alpine Tundra is very cold, located on top of high mountains, often with very few trees and very little vegetative cover. They are icy for a larger part of the year. Animals in this biome include some birds, goats and marmots. There are also beetles and butterflies.

Aquatic Biome

This includes all water bodies on the earth's surface. Aquatic biomes are grouped into two biomes, i.e. **Freshwater Biomes** (lakes and ponds, rivers and streams, wetlands) and **Marine Biomes** (oceans, coral reefs and estuaries). These biomes make up about 73% of the total earth's surface. Life forms in these waters depend on the abiotic factors such as sunlight entering the waters, temperature, pressure, salt content and so on. Water biomes with lots of light tend to have more flora (plant) diversity, and the growth of algae and plankton is more. Small water bodies that freeze during the cold seasons, or dry out in the dry and hot seasons tend to have less diversity. Examples of animals found in marine biomes include star fishes, sharks and tuna and sea birds. Examples of animals in freshwater biomes include salmon, tilapia worms, water-surface insects and crabs.

ENVIRONMENTAL POLLUTION

> *"We live in a land of vanishing beauty, of increasing ugliness, of shrinking open space, and of an overall environment that is diminished daily by pollution and noise and blight."* ***(Stewart L. Udall, U.S. politician and conservationist)***

Pollution is defined as "undesirable change in the physical, chemical or biological characteristics of air, water and land brought about by man's activities that may harmfully affect living organisms and other resources". There are many types of environmental pollution but the most important are:

- Water pollution
- Air pollution
- Land pollution
- Noise Pollution

WATER POLLUTION

Save water to save life

Any change or modification in the physical, chemical and biological properties of water that will have a detrimental consequence on living things is water pollution. Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater), very often by human activities.

Following indicators are used to measure the quality of water: **Dissolved Oxygen, pH** amount of **nutrients** (nitrogen and phosphorus), **toxic substances** (toxic things like metal, pesticides, and mercury), **turbidity and bacteria.**

Water Pollution Sources, Effects And Constituents of Concern

Pollutant type	Primary sources	Effects	Constituents of concern
Organic matter	Industrial wastewater and domestic sewage.	Depletion of oxygen from the water column as it decomposes, stress or suffocating aquatic life.	Biological Materials, Animal & Plant Waste.
Pathogens and microbial contaminants	Domestic sewage, cattle and animal facces.	Spreads infectious diseases through contaminated drinking water supplies leading to diarrhoeal disease and intestinal parasites, increased childhood mortality in developing countries.	Shigella, Salmonella, Cryptosporidium, Fecal coliform Escherichia coli Fungi and virus.
Nutrients	Principally runoff from agricultural lands and urban areas but also from some industrial discharge.	Over-stimulates growth of algae (eutrophication) which then decomposes, depleting oxygen and harming aquatic life.	Nitrates & Phosphates
Acids and alkaline material (Inorganic compounds)	Sulphur, Nitrogen oxides and particulates from electric power generation, industrial stack and auto emissions. Acid mine drainage from tailings as well as mines.	Acidifies lakes and streams which negatively impacts aquatic organisms and leaches heavy metals such as aluminium from soils into water bodies.	Acids & bases such as Sulphuric Acid Hydrochloric Acid etc.
Heavy metals	Industries and mining sites.	Persists in freshwater environments for long periods. Accumulates in the tissues of fish and shellfish. Toxic to both aquatic organisms and humans who consume them.	Pb, Cd, Zn, Cu, Ni, Cr, Hg, As (particularly groundwater).
Toxic organic compounds and micro-organic pollutants	Wide variety of sources from industrial sites, automobiles, farmers, home gardeners, municipal wastewaters.	A range of toxic effects in aquatic fauna and humans from mild immune suppression to acute poisoning or reproductive failure.	PAHs, PCBs, pesticides (Lindane, DDT, PCP, Aldrin, Dieldrin, Endrin, Isodrin, hexachlorobenzene).
Thermal	Fragmentation of rivers by dams and reservoirs slowing water and allowing it to warm. Industry	Changes in oxygen levels and decomposition rate of organic matter in the water column. May shift the species composition of the receiving	Temperature.

	from cooling towers and other end-of-pipe above-ambient temperature discharges.	water body.	

Minimizing water Pollution

There are a number of factors that can be implemented to insure that the water on our earth remains clean. For factories, construction sites, chemical waste facilities and other large buildings that create large amounts of pollution should make sure that their waste is being disposed of properly. **Proper disposal and containment of toxic chemicals** before they have an opportunity to reach our oceans and lakes would go a long way towards improving the current condition of our water.

Secondly, by **implementing renewable energy sources we can reduce pollution.** Large operations companies can obtain their energy from eco-friendly sources that do not harm or pollute the atmosphere. For example solar energy, wind turbines and hydro power are all pollution free methods of obtaining power.

Thirdly, **eco-friendly chemicals** should be used to replace toxic cleaning chemicals, sprays and other supplies. These chemicals are extremely helpful as they do not contaminate the water they come into contact with so if they go down a drain pipe or sewage drain there is little or at least less negative consequence. With that said even eco-friendly chemicals should be disposed of properly and with caution.

Fourthly, **toxic fumes created from industrial zones should be filtered**, rerouted and cleaned before making their way to the atmosphere. Toxic fumes may also contribute to water pollution as they can be carried to different areas by the wind and heavy rainfall can help spread the toxic debris into various water systems.

Fifthly, companies that develop products and goods should focus on developing materials that are **eco-friendly and recyclable.** Sixthly, **reduce, recycle and reuse.** Companies can find better ways to reduce the amount of materials they use to create their products, recycle left-over materials and reuse or re-purpose materials that may not work with their existing products. These are just some of the steps people, companies and organizations that produce toxic waste and pollutants can take to reduce the amount of pollution that hits our waters. Lastly, be a part of the solution, not pollution!!!

DRINKING WATER QUALITY STANDARDS

WHO's Guidelines for Drinking-water Quality, set up in Geneva, 1993, and are the international reference point for standard setting and drinking-water safety. However, a country can either adopt these standards or devise its own because these are not binding on any country.

Pakistan Environmental Protection Agency finalised National Standards for Quality Drinking Water in June 2008. These standards state that drinking water must be free of suspended solids, micro-organisms and toxic chemicals. Let us have a look at these standards.

Standards for Drinking Water Quality

Parameters	**Pakistani Standards**	**WHO Standards**
Bacterial		
E.Coli or Thermo-tolerant	Must not be detectable in any 100	Must not be detectable in any 100

Coliform bacteria	ml sample	ml sample
Physical		
Colour	≤15 True Colour Units	≤15 True Colour Units
Taste	Non objectionable/Acceptable	Non objectionable/Acceptable
Odour	Non objectionable/Acceptable	Non objectionable/Acceptable
Turbidity	‹ 5 NTU (Units)	‹ 5 NTU (Units)
Total hardness as $CaCO_3$	< 500 mg/l	—
TDS	‹ 1000	‹ 1000
pH	6.5-8.5	6.5-8.5
Chemical		
Essential Inorganic	**mg/Litre**	**mg/Litre**
Calcium	200	No Guideline
Magnesium	100	No Guideline
Sodium	200	200
Sulphate	400	500
Nitrate	50	50
Toxic Inorganic	**mg/Litre**	**mg/Litre**
Cyanide (CN)	≤ 0.05	0.07
Lead (Pb)	≤ 0.05	0.01
Manganese (Mn)	≤ 0.5	0.5
Mercury (Hg)	≤ 0.001	0.001

Note: The table given above is reproduced here just to give an idea to the students about standards and it is an incomplete table. There is no need to memorize these values/figures.

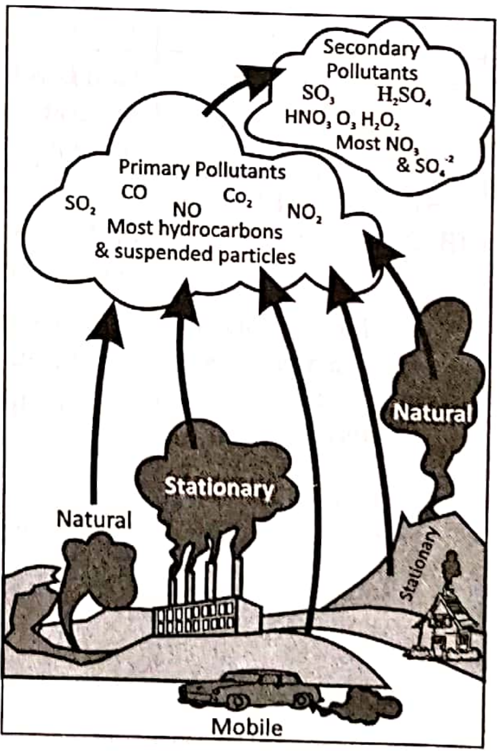
AIR POLLUTION

"Water and air, the two essential fluids on which all life depends, have become global garbage cans." —

(Jacques-Yves Cousteau)

Air pollution occurs when the air contains gases, dust, fumes or odour in harmful amounts. The atmosphere has always been a sink—a place of deposition and storage—for gaseous and particulate wastes. When the amount of waste entering an area of the atmosphere exceeds the atmosphere's ability to disperse or break down the pollutants, problems result.

The substances that cause air pollution are called pollutants. Pollutants that are pumped into our atmosphere and directly pollute the air are called **primary pollutants.**



Primary pollutant examples include carbon monoxide from car exhausts and sulfur dioxide from the combustion of coal. Further pollution can arise if primary pollutants in the atmosphere undergo chemical reactions. The resulting compounds are called **secondary pollutants.** Photochemical smog is an example of secondary pollutants.

Causes of Air Pollution

The two major categories of air pollution sources are **stationery sources** and **mobile sources.** Stationery sources have relatively fixed location. Mobile sources of air pollution include automobiles, trucks, buses, aircraft, ships, trains and anything else that pollutes as it moves from place to place. Following are the causes of air pollution:

1. Exhaust from transportation vehicles
2. Power stations (thermal energy)
3. Agricultural activities (fertilize & pesticide)
4. Emissions from factories & industries
5. Chemical industry, aerosols, CFCs, etc
6. Wildfires & volcanic activity
7. Indoor air pollution

Common Air Pollutants, Sources and Effects

Pollutant	Source	Effect
Carbon monoxide	Incomplete combustion of organic materials wood, coal, oil and gas. Outdoors: vehicle exhausts, heating appliances. Indoors: smoking, heaters (unvented).	Reduces the oxygen-carrying capacity of the blood leading to headache, nausea, vomiting, eventually collapse and death.
Lead	Outdoors: motor vehicle exhausts. Indoors: may be present in water pipes and/or old paint.	Cumulative effects on the nervous system that may impair children's intelligence and concentration.
Nitrogen dioxide	Combustion of fossil fuels, road vehicles, power generation, industrial processes. Indoors: unvented gas cookers and other appliances.	Throat and eye irritation (also involved in photochemical smog formation).
Ground Level Ozone (Bad Ozone)	Product of chemical reaction between other pollutants (Nitrogen oxide and hydrocarbons (VOCs) in the presence of sunlight).	Running eyes, throat irritation, breathing difficulties.
Particulate matter (PM10 particles less than 10 micrometers in diameter)	Combustion processes and natural sources such as dust, diesel and smoke.	Small particles can penetrate deep into the lungs and cannot be expelled. They may cause irritation and/or carry with them toxic or carcinogenic substances.
Sulphur dioxide	Domestic and industrial burning of coal.	Irritation of the nerves in the nose, throat and airways. May also lead to constriction of the airways.

Volatile Organic Compounds, e.g. Formaldehyde	Paints, varnishes, glues and preservatives used in wood products. Foam insulation. Exposure indoors during decoration or construction.	Breathing difficulties, eye and skin irritation, nausea and dizziness.
Micro-organisms and allergens	Biological contaminants, molds, spores, viruses and bacteria.	Pneumonia, respiratory illnesses, allergic reactions.

Control Measures

The atmosphere has several built-in self-cleaning processes such as dispersion, gravitational settling, absorption, rain-washout, etc. to cleanse the atmosphere. However, control of contaminants at their source level is a desirable and effective method through preventive or control technologies.

Source control

Some measures that can be adopted in this direction are:

- Using unleaded petrol
- Using fuels with low sulphur and ash content
- Encouraging people to use public transport, walk or use a cycle as opposed to private vehicles
- Ensure that houses, schools, restaurants and playgrounds are not located on busy streets
- Plant trees along busy streets as they remove particulates, carbon dioxide and absorb noise
- Industries and waste disposal sites should be situated outside the city preferably on the downwind of the city.
- Catalytic converters should be used to help control emissions of carbon monoxide and hydrocarbons

Control measures in industrial centres

- Emission rates should be restricted to permissible levels by each and every industry
- Incorporation of air pollution control equipment in design of plant layout must be made mandatory
- Continuous monitoring of the atmosphere should be carried out to know the emission levels.

Equipment Used To Control Air Pollution

Air pollution can be reduced by adopting the following approaches.

Ensuring sufficient supply of oxygen to the combustion chamber and adequate temperature so that the combustion is complete thereby eliminating much of the smoke consisting of partly burnt ashes and dust.

To use mechanical devices such as **scrubbers, cyclones, bag houses and electro-static precipitators** in manufacturing processes. These methods retain hazardous materials that must be disposed safely. Wet scrubber can additionally reduce sulphur dioxide emissions. The air pollutants collected must be carefully disposed.

LAND POLLUTION

Land pollution, in other words, means degradation or destruction of earth's surface and soil, directly or indirectly as a result of human activities.

Causes of Land Pollution

Solid Waste: Humans produce vast quantities of waste — in factories and offices, in our homes and schools, and in such unlikely places as hospitals. Waste material is sent to landfill site which end up in polluting the environment.

Herbicides, insecticides, and pesticides: With growing human population, demand for food has increased considerably. Farmers often use highly toxic fertilizers and pesticides to get rid of insects, fungi and bacteria from their crops. However, with the overuse of these chemicals, they result in contamination and poisoning of soil.

Mining activities: Surface mining (sometimes called quarrying or opencast mining) requires the removal of topsoil (the fertile layer of soil and organic matter that is particularly valuable for agriculture) to get at the valuable rocks below. Mining remove topsoil from the land, causing pollution. Most metals, for example, occur in rocky mixtures called ores, from which the valuable elements have to be extracted by chemical, electrical, or other processes. That leaves behind waste products. These waste products pollute land air and water.

Urbanisation and Industrialisation: Due to increase in demand for food, shelter and house, more goods are produced. This resulted in creation of more waste that needs to be disposed of. To meet the demand of the growing population, more industries were developed which led to deforestation.

Chemical and nuclear waste: Nuclear plants can produce huge amount of energy through nuclear fission and fusion. The leftover radioactive material contains harmful and toxic chemicals that can affect human health. They are dumped beneath the earth to avoid any casualty.

Deforestation and soil erosion: Deforestation carried out to create dry lands is one of the major concerns. Land that is once converted into a dry or barren land, can never be made fertile again, whatever the magnitude of measures to redeem it are.

Land conversion: Land conversion, meaning the alteration or modification of the original properties of the land to make it use — worthy for a specific purpose is another major cause.

Effects of Land Pollution

Groundwater Poisoning in Landfills: Water percolating through garbage dumps and landfills can introduce toxins like arsenic into groundwater, causing a host of illnesses including birth defects. "E-waste," garbage produced by improper disposal of computers and other electronic devices, introduces toxic chemicals like lead and cadmium into the water tables through leaching.

Damages Food Safety: Many toxic pollutants enter plants from contaminated soil. The toxins in contaminated plants accumulate in the tissues of animals that consume the plants and pass up the food chain to higher trophic levels, as each animal in the food chain becomes prey. Some contaminants increase in concentration in tissues from one trophic level to the next, a process called bio-magnification. Polychlorinated biphenyls (PCBs) and dioxin-like compounds accumulate in fatty tissues of animals and humans. Humans acquire dioxins by eating contaminated meat, dairy products and fish.

Effect on human health: The land when contaminated with toxic chemicals and pesticides lead to problem of skin cancer and human respiratory system. The toxic chemicals can reach our body through foods and vegetables that we eat as they are grown in polluted soil.

Burning of waste and Air pollution: Landfills across the city keep on growing due to increase in waste and are later burnt which leads to air pollution. They become home for rodents, mice, etc. which in turn transmit disease.

Destruction of Scenic beauty: Land pollution causes destruction of scenic beauty and consequently the city loses its attraction as tourist destination. It leads to loss of revenue for the government.

Loss of biodiversity: The plant and animal kingdom has suffered in the past due to loss of habitat and destruction of natural environment. Human activities on land are leaving it polluted; forcing these species to move further away and adapt to new regions or cause their death. Several species are pushed to the verge of extinction, due to loss or fragmentation of their habitat.

How to Prevent Land Pollution

1. People should be educated and made aware about the harmful effects of littering.
2. Reuse any item that you can. Items like clothing, bottles, wrapping paper and shopping bags can be used over and over again, rather than buying new things. The greatest prevention to land pollution is in the three 'Rs'. Reduce Waste, Re-use things and Recycle things.
3. Personal litter should be disposed properly. We can separate household waste at home for recycling. More than half of our household waste could be recycled or re-used but once it is mixed up, it becomes more difficult to separate different components for recycling.
4. Buy biodegradable products.
5. Store all liquid chemicals and waste in spill-proof containers.
6. Don't use pesticides if you can.
7. Buy products that have little packaging.
8. Plant more trees on barren and clear areas
9. Reclaim the contaminated soils
10. Apply scientific waste management system to dispose waste

SOLID WASTE MANAGEMENT (SWM)

> *"Solid wastes" are the discarded leftovers of our advanced consumer society. This growing mountain of garbage and trash represents not only an attitude of indifference toward valuable natural resources, but also a serious economic and public health problem.*
>
> ***(Jimmy Carter)***

Solid waste: Any refuse or waste material, including semi solid sludge, produced from domestic, commercial, or industrial premises or processes including mining and agricultural operations and water treatment plants. **Solid Waste Management** (SWM) refers to the systematic management of the generation, collection, transfer, treatment, recycling, recovery and disposal of solid waste.

Categorisation of Solid Waste

The solid waste composition varies from region to region and time to time. It may be categorized according to its **origin** (domestic, industrial, commercial, construction or institutional); according to its **contents** (organic material, Inorganic.); or according to **hazard potential** (toxic, non-toxin, flammable, radioactive, infectious etc.).

Classification of wastes according to their origin and type

- **Municipal solid wastes:** Solid wastes that include household garbage, rubbish, construction & demolition debris, sanitation residues, packaging materials, trade refuges etc. are managed by any municipality.
- **Bio-medical wastes:** Solid or liquid wastes including containers, intermediate or end products generated during diagnosis, treatment and research activities of medical sciences.
- **Industrial wastes:** Liquid and solid wastes that are generated by manufacturing and processing units of various industries like chemical, petroleum, coal, metal gas, sanitary & paper etc.
- **Agricultural wastes:** Wastes generated from farming activities. These substances are mostly biodegradable.
- **Fishery wastes:** Wastes generated due to fishery activities. These are extensively found in coastal & estuarine areas.
- **Radioactive wastes:** Waste containing radioactive materials. Usually these are by products of nuclear processes.
- **E-wastes:** Electronic wastes generated from any modern establishments. They may be described as discarded electrical or electronic devices.

Hazardous waste is any waste or combination of waste that poses a substantial danger, now or in the future, to human, plant or animal life and which, therefore, cannot be handled or disposed of without special precautions. There are four criteria to classify any waste as hazardous waste, these are:

- **Ignitability:** substances catch fire.
- **Corrosivity:** substances corrode metals.
- **Reactivity:** substances are chemically unstable and react with other chemicals in dangerous ways.
- **Toxicity:** substances are known to be harmful to human health.

The hazardous solid waste is being generated in Pakistan from the following sectors: agriculture, hospitals and clinical laboratories, industries, oil refineries and household.

Key Issues in Solid Waste Management in Pakistan

According to a World Bank report current global municipal solid waste generation levels are approximately 1.3 billion tonnes per year, and are expected to increase to approximately 2.2 billion tonnes per year by 2025. Total solid waste generation in Pakistan is about 20.024 million tons a year, which is approximately 59,000 tons per day, according to a Pakistan Ministry of Environment study. This study also revealed that the rate of waste generation on average varies from 0.23 kg/capita/day to 0.61 kg/capita/day in rural and urban areas, respectively. The study also shows that the growth rate of solid waste generation is about 2.4% per annum.

The increase in household size in major cities like Karachi, Hyderabad, Faisalabad, Rawalpindi, Peshawar, etc. is the foremost factor affecting the solid waste and its management at different stages. These cities are expected to double their populations in the next 10 years. As a result, the amount of waste being generated ranges from 1.896 kg/house/day to 4.29 kg/house/day which is increasing annually with respective to population growth. However, the rate of solid waste collection in these cities ranges from just 51% to 69% of the total waste generated.

Unfortunately there is no single city in Pakistan which has a proper scientific solid waste management system (SWM) right from collection of solid waste up to disposal. Even cosmopolitan cities like Karachi and Lahore do not have any appropriate landfill or disposal site, instead, un-engineered landfilling, open dumping and open burning is being practised. In Lahore, the collection process is smooth that also only in central part of the city. Waste collection and transportation system is in very bad condition in outskirts. Similarly, solid waste management in Karachi is in worst form, rather there is no waste management at all.

Open dumping, open burning and un-engineered sanitary landfilling are the usual methods of solid waste disposal causing environmental degradation and posing great threats to environmental sustainability in Pakistan. Unplanned urbanization, poor sanitation, ill-planned drainage systems, inadequate human and capital resources for collection and disposal of waste, unavailability of official dumping sites, absence of weigh bridges for exact measurement of waste received at these sites, and almost negligible presence of recycling processes have negatively impacted waste management in the country.

The government has to work on the development and implementation of a standardized SWM system. Environmental legislation is still not well developed in Pakistan and the existing rules and regulations dealing with solid waste management are inadequate and outdated.

Solid Waste Management System

The activities associated with the management of municipal solid waste can be grouped into:

(a) waste generation
(b) waste handling and sorting, storage, and processing at the source
(c) collection
(d) sorting, processing and transformation
(e) transfer and transport; and
(f) disposal

Waste Generation

Waste generation encompasses activities in which materials no longer considered of value are either thrown away or gathered together for disposal.

Waste Handling and Processing at the Source, including Sorting and Storage

These are activities associated with the management of wastes until they are gathered or placed in bags or storage containers for collection. Handling encompasses the movement of the waste or loaded containers and bags to the point of collection. Sorting of waste components is an important step in the handling and storage of solid waste at the source. Separation of saleable items such as newspaper and cardboard, bottles/glass, plastic ware, electrical appliances, metal parts and pieces, old shoes, clothes, bags, etc. is carried out prior to their temporary storage and consequent sale or re-use. Composting of kitchen waste is an example of processing at the point of generation.

Collection

Collection includes the gathering and transport of solid wastes and recyclable materials, by means of vehicle, cart or other facility, to the location where the collection vehicle is emptied. This location may be a transfer station, or a landfill disposal site. Collection is carried out through two stages:

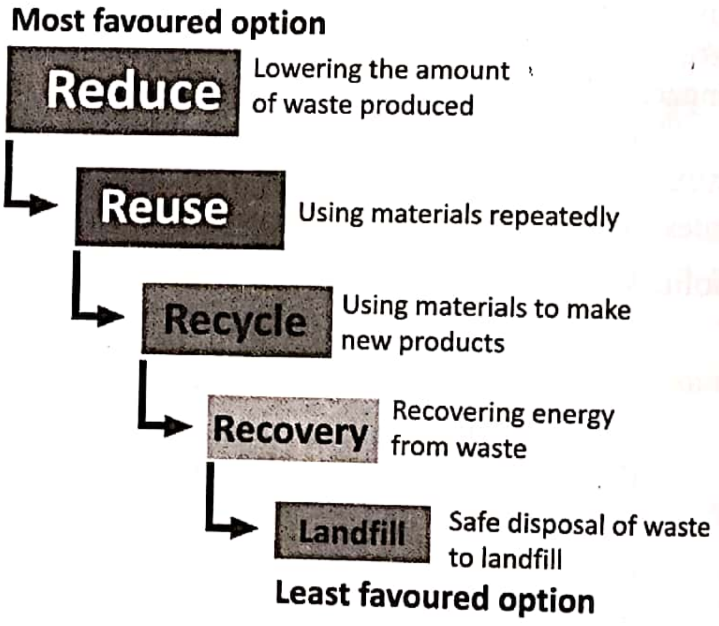
- **Primary Collection:** The means by which solid waste is collected from its source (domestic and commercial premises also called Primary Collection Points) and transported to communal stations, transfer points or disposal sites.
- **Secondary Collection:** The collection of solid waste from a communal collection or transfer point (Secondary Collection Points) and its transport to a transfer station, recycling centre, intermediate treatment facilities or disposal site.

Transfer and Transport

The transfer and transport of solid waste involves two steps: (i) the transfer of wastes from the secondary collection point to the larger transport equipment or transfer point, and (ii) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site.

Waste Disposal

Disposal is the process of final placement of solid waste with and or without previous treatment processing and or recycling in a landfill. It can be defined as the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into - or on - land or water. **Landfill** means a disposal facility or a part of a facility where waste is placed in or on land and is not a land treatment facility. Landfill cell means a discrete volume of a waste landfill that uses a liner to provide isolation of wastes from adjacent cells or wastes. Examples of landfill cells are trenches and pits.


Most favoured option
Reduce
Lowering the amount of waste produced
Reuse
Using materials repeatedly
Recycle
Using materials to make new products
Recovery
Recovering energy from waste
Landfill
Safe disposal of waste to landfill
Least favoured option

Waste Hierarchy Concept

No single waste management approach is suitable for managing all materials and waste streams in all circumstances. The waste management hierarchy ranks the various management strategies from most to least environmentally preferred. The hierarchy places emphasis on reducing, reusing, and recycling as key to sustainable materials management. The waste hierarchy concept was introduced formally for the first time by the European Union's Waste

Framework Directive of 1975 as a SWM policy. The hierarchy usually adopted is (a) Source reduction and reuse, (b) recycling, (c) energy recovery, and (d) treatment and disposal.

Source Reduction and Reuse

Source reduction, also known as waste prevention, means reducing waste at the source, and is the most environmentally preferred strategy. It can take many different forms, including, reducing packaging, redesigning products, and reducing toxicity. Source reduction also is important in manufacturing. Light weighting of packaging, reuse, and remanufacturing are all becoming more popular business trends. Purchasing products that incorporate these features supports source reduction. Source reduction can: save natural resources, conserve energy, reduce pollution, reduce the toxicity of our waste, and save money for consumers and businesses alike.

We can save environment and conserve resources by **reusing** materials and products. Shopping bags can reused to store things at home or to collect waste materials. Disposable bottles can be used further to store cool water or other Liquids. Similarly, old clothes can be made into other textile items such as cushion covers etc.

Recycling and composting

Recycling is a series of activities that includes collecting used, reused, or unused items that would otherwise be considered waste; sorting and processing the recyclable products into raw materials; and remanufacturing the recycled raw materials into new products. Recycling also can include **composting** of food scraps, yard trimmings, and other organic materials to form compost. Benefits of recycling include: preventing the emission of many greenhouse gases and water pollutants; saving energy; suppling valuable raw materials to industry; creating jobs; stimulating the development of greener technologies; conserving resources for our children's future; and reducing the need for new landfills and combustors.

Energy Recovery

Energy recovery from waste is the conversion of non-recyclable waste materials into useable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion, and landfill gas (LFG) recovery. This process is often called waste-to-energy (WTE). Converting non-recyclable waste materials into electricity and heat generates a renewable energy source and reduces carbon emissions by offsetting the need for energy from fossil fuels and reduces methane generation from landfills. After energy is recovered, approximately 10% of the volume remains as ash, which is generally sent to a landfill.

Treatment and Disposal

Prior to disposal, treatment can help reduce the volume and toxicity of waste. Treatments can be physical (e.g. shredding), chemical (e.g. incineration), and biological (e.g. anaerobic digestor). Landfills are the most common form of waste disposal and are an important component of an integrated waste management system.

Landfill

A landfill is a carefully designed structure built into or on top of the ground, in which trash is separated from the area around it. Landfills contain garbage and serve to prevent contamination between the waste and the surrounding environment, especially groundwater.

Types of landfills

- **Sanitary landfills:** Sanitary landfills accept hazardous wastes such as hospital waste. Sanitary landfills use technology to contain the waste and prevent the leaching out of potentially hazardous substances.
- **Municipal solid waste (MSW) landfills** - Landfills that accept household waste as well as other wastes.
- **Construction and demolition waste landfills:** These types of landfills used for debris generated during construction, renovations, demolitions of buildings and bridges.
- **Industrial waste landfills:** Industrial hazardous waste is a separate form of waste consisting of non-hazardous waste associated with manufacturing and other industrial activities.

Structure of a Landfill

The structure and main components of any secured, permitted landfill are given below.

Bottom liner: The bottom liner separates and prevents the buried waste from coming in contact with underlying natural soils and groundwater. In Municipal Solid Waste landfills, the bottom liners are generally constructed using some type of durable, puncture-resistant synthetic plastic HDPE (High Density Polyethylene). The plastic liners may also be designed with a combination of compacted clay soils, along with synthetic plastic.

Cells: This is the area in a landfill that has been constructed and approved for disposal of waste. These cells range in size from a few acres to as large as 20+acres. This is where the waste coming into the landfill for disposal is prepared by placing the material in layers then compacted and shredded by heavy landfill compaction machinery.

Leachate collection system: The bottom of each landfill is typically designed so that the bottom surface of the landfill is sloped to a low point, called a sump. This is where any liquids called leachate that are trapped inside the landfill are collected, removed from the landfill and treated thereof.

Methane collection system — Bacteria in the landfill break down the trash in the absence of oxygen. This process produces landfill gas, which is approximately 50% methane. Since methane gas has the potential to burn or explode, it has to be removed from the landfill. To do this, a series of pipes are embedded within the landfill to collect the methane gas. This gas, once collected, can be either naturally vented or control-burned. This landfill gas can be used to produce electricity at a small power plant. It can be used as alternative fuel and can be piped to a nearby industrial or commercial facility. Landfill gas can be processed and cleaned to natured gas quality and can be sold to households.

Cover (or cap): Waste that is placed in a cell is required to be covered daily with either six inches of compacted soil or an alternative daily cover. Covering (or capping) is performed in order to isolate the waste from exposure to the air, pests (such as birds, rats and mice) and to control odors. When a section of the landfill is finished or filled to capacity, it is permanently covered with a combination of a layer of polyethylene plastic, compacted soil and a layer of topsoil that will support growth of vegetation to prevent erosion.

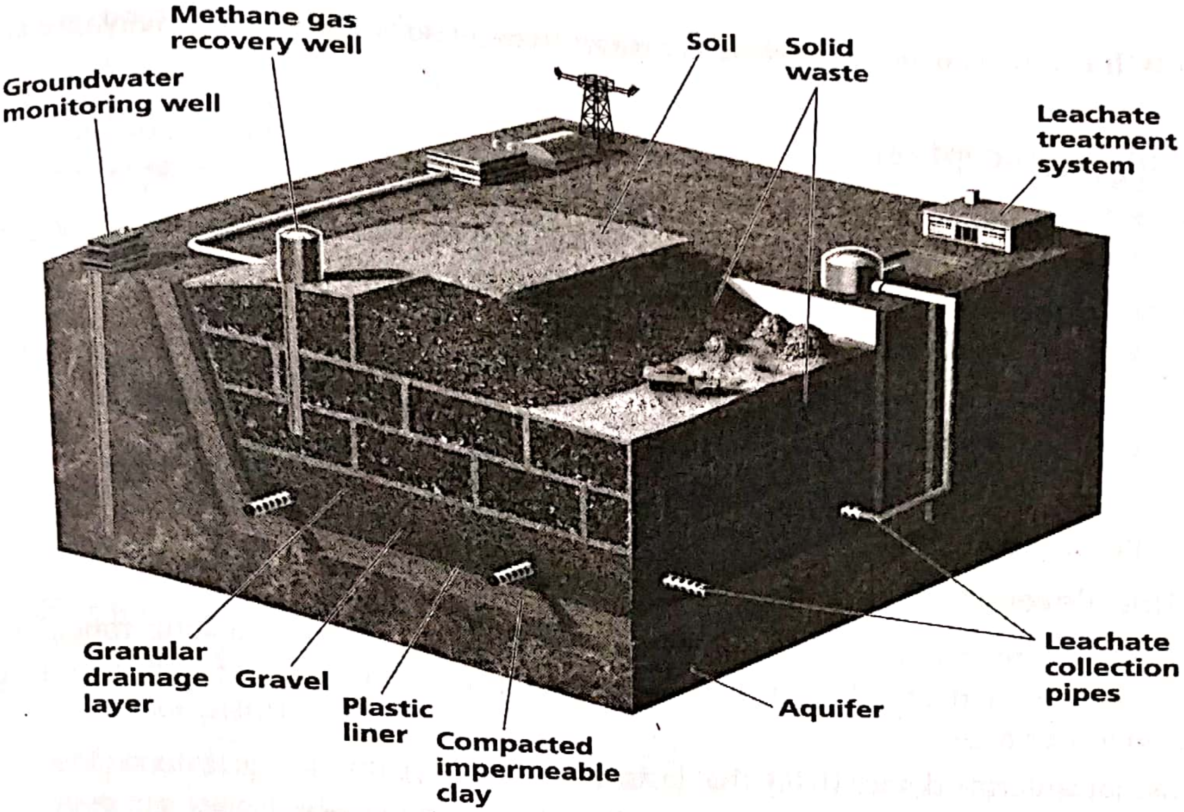

Methane gas recovery well
Groundwater monitoring well
Soil
Solid waste
Leachate treatment system
Granular drainage layer
Gravel
Plastic liner
Compacted impermeable clay
Aquifer
Leachate collection pipes

Figure: Landfill Structure

Groundwater monitoring stations: These stations are set up to directly access and test the groundwater around the landfill for presence of leachate chemicals.

POPULATION PLANNING

"When we first set up WWF, our objective was to save endangered species from extinction. But we have failed completely; we haven't managed to save a single one. If only we had put all that money into condoms, we might have done some good."

Sir Peter Scott, founder of WWF (1909 – 1989)

The current world population of 7.3 billion is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion in 2100, according to a UN report, "World Population Prospects: The 2015 Revision". The population of Pakistan was 32.5 million in 1951, at that time it was the 14th most populous country in the world. Its population has since increased approximately 5.5-fold, reaching 184.5 million in 2012-13. Pakistan is now the sixth most populous country in the world. The current population growth rate is 2%. According to estimates, Pakistan will become the fifth most populous country in 2050 at its current rate of population growth.

Population planning is a structured way of thinking and taking action to improve the lives of children, families and communities as a whole. Human population control is the practice of artificially altering the rate of growth of a human population and it involve measures that improve people's lives by giving them greater control of their reproduction.

Family Planning and Contraception

As defined by the World Health Organization, family planning allows individuals and couples to anticipate and attain their desired number of children and the spacing and timing of their births. It is achieved through use of contraceptive methods and the treatment of involuntary fertility.

Method of contraception

There are different methods of contraception, including:

- long-acting reversible contraception, such as an implant, or an intra uterine device
- hormonal contraception such as contraceptive pills – "the pill", the injection and vaginal rings
- barriers methods, such as condoms and diaphragms
- fertility awareness
- emergency contraception
- Permanent contraception, such as vasectomy and tubal ligation.

Long-acting Reversible Contraception

Long-acting reversible (LARC) are contraceptives that lasts for a long time. User don't need to remember it every day or even every month. There are two types of long-acting reversible contraceptives:

- an intrauterine device (IUD) that lasts five or more years
- an implant under the skin that lasts either three or five years

These types of contraception last longer so are more effective at preventing pregnancy because couples don't have to worry about forgetting pills or a condom breaking or coming off.

Hormonal Contraceptives

Hormonal contraceptives can be administered in two forms that is contraceptive pills and injections. Contraceptive Pill is one of the most popular contraceptive methods in Pakistan. The Pill and injections come, in two forms:

- Combined oral contraceptive pill /injection
- Progestogen-only contraceptive pill/ injection

Both are taken daily and are over 99% effective at preventing pregnancy when taken correctly. Combined Oral Contraceptive Pills and injections contain low doses of two hormones, a 'progestin' and an 'oestrogen', like the natural hormones progesterone and oestrogen in a woman's body. Progestogen-Only Pills and injections contain very low doses of a 'progestin' like the natural hormone progesterone in a woman's body. These hormones pedants pregnancy by stopping ovulation. If no egg is released there is nothing to be fertilised by sperm and the woman cannot get pregnant. These hormones prevents pregnancy by stopping ovulation. If no egg is released there is nothing to be fertilised by sperm and the woman cannot get pregnant.

Emergency Contraception

Emergency Contraception (EC) is a method used by a woman to prevent an unwanted pregnancy after unprotected sexual intercourse. Emergency Contraceptive Pills (ECPs) should be used within 120 hours (five days) after unprotected intercourse. Their effectiveness depends upon the time period elapsed between coitus and taking the method - the earlier the pills are taken the more the chances of effectiveness. Types of ECPs available are:

- Oral contraceptives pills containing only progestin

- Oral contraceptive pills (COCs) containing oestrogen and progestin

Barrier methods

Barrier methods stop sperm from entering the vagina. There are three main barrier methods of contraception: male condoms, female condoms and diaphragms

Condoms: These are sheaths, or coverings, that fit over a man's erect penis. Most are made of thin latex rubber. Condoms protect against sexually transmissible infections (STIs) as well as unwanted pregnancy.

Female condoms: The female condom is a patch that is made out of poly urethane and has a flexible ring at each end. It is inserted deep into vagina.

Diaphragm: A diaphragm (with spermicide) is inserted into a woman's vagina before intercourse. It must always be used with spermicide. It is cup shaped & made up of latex.

Fertility awareness

Fertility awareness is recognising the signs of fertility in a woman's menstrual cycle. It can be used to understand menstrual cycle, plan a pregnancy or avoid a pregnancy.

Permanent contraception

Permanent contraception is sterilisation that permanently prevents pregnancy. The procedure for men is a vasectomy and for women it is tubal ligation.

Vasectomy: When a man is sterilized, the operation is called a vasectomy. When a person ejaculates the fluid or semen is produced that contains sperm. Sperm are made in testicles (balls) and travel up to vas deferens (tubes) to mix with semen. These are the tubes that are cut and tied when someone has a vasectomy. After a vasectomy there are no sperm in semen. Testicles still make sperm but they are absorbed by the body.

Tubal Ligation: A tubal ligation is a procedure to cut or clip a woman's fallopian tubes. When a woman is sterilised, the operation is called a tubal ligation. It is a procedure to close both fallopian tubes which means that sperm can't get to an egg to fertilise it. The tubes are closed using rings or clips or by cutting and tying.

Benefits of Population (Family) Planning

Promotion of family planning – and ensuring access to preferred contraceptive methods for women and couples – is essential to securing the well-being and autonomy of women, while supporting the health and development of communities.

Preventing pregnancy-related health risks in women: A woman's ability to choose if and when to become pregnant has a direct impact on her health and well-being. Family planning allows spacing of pregnancies and can delay pregnancies in young women at increased risk of health problems and death from early childbearing. It prevents unintended pregnancies, including those of older women who face increased risks related to pregnancy. Family planning enables women who wish to limit the size of their families to do so. By reducing rates of unintended pregnancies, family planning also reduces the need for unsafe abortion.

Reducing infant mortality: Family planning can prevent closely spaced and ill-timed pregnancies and births, which contribute to some of the world's highest infant mortality rates. Infants of mothers who die as a result of giving birth also have a greater risk of death and poor health.

Helping to prevent HIV/AIDS: Family planning reduces the risk of unintended pregnancies among women living with HIV, resulting in fewer infected babies and orphans. In addition, male and female condoms provide dual protection against unintended pregnancies and against sexually transmitted infections including HIV.

Empowering people and enhancing education: Family planning enables people to make informed choices about their sexual and reproductive health. Family planning represents an opportunity for women to pursue additional education and participate in public life, including paid employment in non-family organizations. Additionally, having smaller families allows parents to invest more in each child. Children with fewer siblings tend to stay in school longer than those with many siblings.

Reducing adolescent pregnancies: Pregnant adolescents are more likely to have preterm or low birth-weight babies. Babies born to adolescents have higher rates of neonatal mortality. Many adolescent girls who become pregnant have to leave school. This has long-term implications for them as individuals, their families and communities.

Slowing population growth: Family planning is key to slowing unsustainable population growth and the resulting negative impacts on the economy, environment, national and regional development efforts.

Global Unmet Need for Contraception

An estimated 222 million women in developing countries would like to delay or stop childbearing but are not using any method of contraception. Reasons for this include:

- limited choice of methods;
- limited access to contraception, particularly among young people, poorer segments of populations;
- fear or experience of side-effects;
- cultural or religious opposition;
- poor quality of available services.

Contraceptive use has increased in many parts of the world, especially in Asia and Latin America, but continues to be low in sub-Saharan Africa. In Pakistan 25% of married women have an unmet need for family planning. Use of contraception by men makes up a relatively small subset of the above prevalence rates.

ENVIRONMENTAL SCIENCE (MCQS)

Note: Answers are Bold and Underlined.

1. The densest of all the atmosphere layers is:

(a) Troposphere (b) Stratosphere (c) Mesosphere (d) Ionosphere

2. All are particulate pollutants except:

(a) Dust (b) **Ozone** (c) Soot (d) Smoke

3. Which of the following is a secondary pollutant?
(a) CO_2 (b) CO (c) O_3 (d) SO_2

4. The supersonic jets cause pollution by the thinning of:
(a) CO_2 layer (b) SO_2 layer (c) O_3 layer (d) O_2 layer

5. Carbon monoxide is a pollutant because:
(a) It reacts with O_2 (b) It inhibits glycolysis
(c) Makes nervous system inactive (d) Reacts with haemoglobin

6. Which material accounts for the greatest percentage of the weight of solid waste?
(a) Food waste (b) Plastic (c) Paper (d) Yard waste

7. Typical modern municipal landfills contain which of the following?
(a) Monitoring wells (b) Impermeable barriers
(c) Methane retrieval systems (d) All of these

8. Pollutants resulting from human activities are mainly discharged in:
(a) Overpopulated cities (b) Industrial centres
(c) Rural area (d) Both (a) and (b)

9. Atmospheric pollution may be caused by:
(a) Forest fire (b) Organic decay
(c) Automobile exhausts (d) All of these

10. Example of primary pollutants is:
(a) SO_2 (b) NO_2 (c) CO (d) All of these

11. Example of secondary pollutants is:
(a) Smog (b) O_3 (c) PAN (d) All of these

12. Oxidation of sulfur in the fossil fuels mainly produces:
(a) NO (b) SO_3
(c) SO_2 (d) Both (b) and (c)

13. Carbon dioxide content in atmosphere is:
(a) 93% (b) 0.5% (c) 0.03% (d) 0.001%

14. The polluting strength of sewage is usually characterized by its:
(a) BOD (b) Nitrogen content
(c) Ozone content (d) Eutrophication

15. Which of the following on inhalation dissolved in the blood hemoglobin more rapidly than oxygen?
(a) Sulphur dioxide (b) Carbon monoxide
(c) Ozone (d) Nitrous oxide

16. Smog is:
(a) A natural phenomenon (b) A combination of smoke and fog
(c) Is colourless (d) All of these

17. **The major photochemical oxidant is:**
(a) **Ozone**
(b) Hydrogen peroxide
(c) Nitrogen oxides
(d) Peroxyl Acetyl Nitrate (PAN)

18. **Which of the following are likely to be present in photochemical smog?**
(a) Sulphur dioxide
(b) Photochemical oxidants
(c) Volatile organic compounds
(d) **All of these**

19. **Which of the following devices is suitable for the removal of gaseous pollutants?**
(a) Cyclone separator
(b) Electrostatic precipitator
(c) Baghouse filter
(d) **All of these**

20. **Which of the following air pollution control devices is suitable for the removing the finest dust from the air?**
(a) Cyclone separator
(b) Electrostatic precipitator
(c) **Fabric filter or baghouse**
(d) Wet scrubber

21. **Biochemical Oxygen Demand measures:**
(a) Industrial pollution
(b) Air pollution
(c) Pollution capacity of effects
(d) **Dissolved O_2 needed by microbes to decompose organic waste**

22. **Fluoride pollution mainly affects:**
(a) Kidney
(b) Brain
(c) Heart
(d) **Teeth**

23. **Which of the following is a non-point source of water pollution?**
(a) Factories
(b) Sewage treatment plants
(c) **Urban and suburban lands**
(d) All of these

24. **Disease caused by eating fish inhabiting mercury contaminated water is:**
(a) Bright's disease
(b) Hiroshima episode
(c) **Mina-mata disease**
(d) Osteosclerosis

25. **Which of the following is not a marine pollutant?**
(a) Oil
(b) Plastics
(c) **Dissolved oxygen**
(d) All of these

26. **Noise is:**
(a) Loud sound
(b) Sound of high frequency
(c) **Unwanted sound**
(d) Constant sound

27. **Sound becomes hazardous noise pollution at ____________ decibels.**
(a) Above 30
(b) **Above 80**
(c) Above 100
(d) Above 120

28. **Which of the following is a major source of thermal pollution in water bodies?**
(a) Sewage treatment plant
(b) Solid waste disposal sites
(c) **Thermal power plant**
(d) All of these

29. **The highest heating valve is of:**
(a) Garbage
(b) Rubbish
(c) Hospital waste
(d) **Industrial waste**

30. **Which of the following is a likely characteristic of hazardous waste?**
(a) Ignitability
(b) Corrosivity
(c) Reactivity
(d) **All of these**

31. **High level radioactive waste can be managed in which of the following ways?**
(a) Open dumping
(b) Composting
(c) Incineration
(d) **Deep well injection**

32. **Biomedical waste may be disposed of by:**
(a) Incineration
(b) Autoclaving
(c) Deep burial
(d) **All of these**

33. **Which of the following is a biodegradable organic chemical/substance?**
(a) Plastics
(b) **Oils**
(c) Pesticides
(d) Garbage

34. **What is the harm from the depletion of Earth's ozone layer?**
(a) The average temperature of earth's surface will increase gradually.
(b) The oxygen content of the atmosphere will decrease.
(c) **Increased amount of Ultra violet radiation will reach earth's surface.**
(d) Sea levels will rise as the polar ice caps will gradually melt.

35. **Acid rain is formed due to contribution from the following pair of gases:**
(a) Methane and ozone
(b) Oxygen and nitrous oxide
(c) Methane and sulphur dioxide
(d) **Carbon dioxide and sulphur dioxide**

36. **Which of the following is a prime health risks associated with greater UV radiation through the atmosphere due to depletion of stratospheric ozone?**
(a) Damage to digestive system
(b) Increased liver cancer
(c) Neurological disorder
(d) **Increased skin cancer**

37. **The most serious environmental effect posed by hazardous wastes is:**
(a) Air pollution.
(b) **Contamination of groundwater.**
(c) Increased use of land for landfills.
(d) Destruction of habitat.

38. **The depletion in the Ozone layer is caused by:**
(a) Nitrous oxide
(b) Carbon dioxide
(c) **Chlorofluorocarbons**
(d) Methane

39. **The presence of high coliform counts in water indicate:**
(a) **Contamination by human wastes.**
(b) Phosphorus contamination.
(c) Decreased biological oxygen demand.
(d) Hydrocarbon contamination.

40. **How the biological oxygen demand gets affected with the increased presence of organic matter in water?**
(a) **The oxygen demand increases.**
(b) The oxygen demand decreases.
(c) The oxygen demand remains unchanged.
(d) None of these

41. **Which of the following is a major air pollutant?**
(a) Hormones
(b) Barrier methods
(c) Sterilization
(d) **All of these**

42. **Which of the following is considered as part of population planning?**

(a) Hormones **(b)** Barrier methods

(c) Sterilization **(d)** All of these.

43. **How much percentage of total water on earth is stored in oceans?**

(a) 97 % **(b)** 70 % **(c)** 78 % **(d)** 21%.

44. **Which of the following is not a major air pollutant?**

(a) Co$_2$ **(b)** So$_3$

(c) Nitrogen gas **(d)** No$_2$

45. **The three primary soil macronutrients are:**

(a) Carbon, oxygen, and water **(b)** Copper, cadmium, and carbon

(c) Potassium, phosphorus, and nitrogen **(d)** Boron, zinc, and manganese

46. **Which of the following is negative effects on the soil and water due to conventional, mechanized farming practices?**

(a) Soil compaction **(b)** Reduction in soil organic matter

(c) Soil erosion **(d)** All of these

47. **What is the correct sequence of the different layers of atmosphere as one proceeds upwards from the earth's surface?**

(a) Troposphere, Ionosphere, Stratosphere, Exosphere.

(b) Stratosphere, Exosphere, Ionosphere, Troposphere.

(c) Troposphere, Stratosphere, Ionosphere, Exosphere.

(d) Ionosphere, Stratosphere, Exosphere, Troposphere.

48. **The altitude of troposphere at equator is:**

(a) 0-5 km **(b)** 0-12 km **(c)** 0-16 km **(d)** 0-80 km

49. **The altitude Mesosphere at equator is:**

(a) 0-5 km **(b)** 0-12 km **(c)** 0-16 km **(d)** 0-80 km

50. **The boundary between the troposphere and stratosphere is called:**

(a) Ozone layer **(b)** Tropopause **(c)** Mesosphere **(d)** None of these

CHAPTER 4

CLIMATE CHANGE

Climate change does not respect border; it does not respect who you are rich and poor, small and big. Therefore, this is what we call 'global challenges,' which require global solidarity.
(Ban Ki-moon)

CLIMATE CHANGE AND GLOBAL WARMING

The United Nations Framework Convention on Climate Change (UNFCCC) defines **climate change** as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". **Global warming** refers to the recent and ongoing rise in global average temperature near Earth's surface. Global warming is causing climate patterns to change. However, global warming itself represents only one aspect of climate change.

Causes of Climate Change

Geological records stretching back millions of years indicate some large variations in climate. These have been caused by many natural factors, including the changes in the sun, volcanoes, earth's orbit and CO_2 levels. However, there is good evidence to show that the current rapid warming is not primarily a natural change. Rather this is likely to be due to human CO_2 emissions.

Changes in the Sun's energy

Climate is influenced by natural changes that affect how much solar energy reaches Earth. These changes include changes within the sun and changes in Earth's orbit. Changes occurring in the sun itself can affect the intensity of the sunlight that reaches Earth's surface. The intensity of the sunlight can cause either warming (during periods of stronger solar intensity) or cooling (during periods of weaker solar intensity). Changes in solar energy continue to affect climate. However, solar output has been lower than it has been since the mid-20th century, and, therefore, does not explain the recent warming of the earth.

Changes in reflectivity of Earth's atmosphere and surface

When sunlight reaches Earth, it can be reflected or absorbed. The amount that is reflected or absorbed depends on Earth's surface and atmosphere. Light-coloured objects and surfaces, like snow and clouds, tend to reflect most sunlight, while darker objects and surfaces, like the ocean, forests, or soil, tend to absorb more sunlight. Human changes in land use and land cover have changed Earth's reflectivity. Processes such as deforestation, desertification, and urbanization often contribute to changes in climate in the places they occur. These effects may be significant regionally, but are smaller when averaged over the entire globe.

Volcanism

The eruptions considered to be large enough to affect the Earth's climate on a scale of more than 1 year are the ones that inject over 0.1 million tonne of SO_2 into the atmosphere. This is due to the optical properties of SO_2 and sulphate aerosols, which strongly absorb or scatter solar radiation, creating a global layer of sulfuric acid haze. On average, such eruptions occur several times per century, and cause cooling (by partially blocking the transmission of solar radiation to the Earth's surface for a period of a few years).

Plate tectonics

Over the course of millions of years, the motion of tectonic plates reconfigures global land and ocean areas and generates topography. This can effect both global and local patterns of climate and atmosphere-ocean circulation. The position of the continents determines the geometry of the oceans and therefore influences patterns of ocean circulation. The locations of the seas are important in controlling the transfer of heat and moisture across the globe, and therefore, in determining global climate.

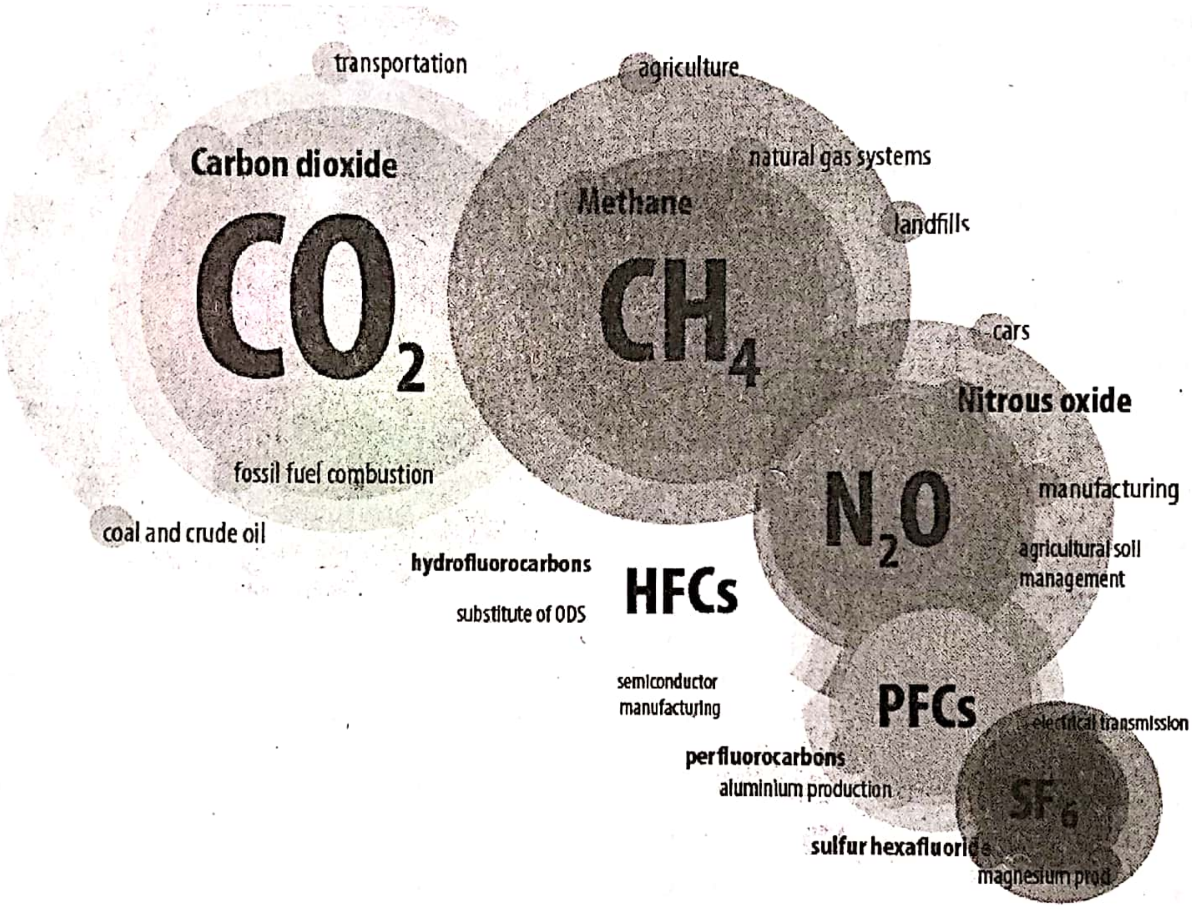


Figure: Greenhouse Gases and their Sources

Anthropogenic Factors

The greenhouse effect is the process by which absorption and emission of infrared radiation by gases in a planet's atmosphere warm its lower atmosphere and surface. On Earth, naturally occurring amount of greenhouse gases have a mean warming effect of about 15° C (59°F). Without the Earth's atmosphere, the Earth's average temperature would be well below the freezing temperature of water. The major greenhouse gases are water vapour, carbon dioxide (CO_2), methane (CH_4), and ozone (O_3).

Human activity since the Industrial Revolution has increased the amount of greenhouse gases in the atmosphere, leading to increased radioactive forcing from CO_2, methane, tropospheric ozone, CFCs and nitrous oxide. According to a research published in 2007, the concentrations of CO_2 and methane have increased by 36% and 148%, respectively since 1750. These levels are much higher than at any time during the last 800,000 years, the period for which reliable data has been extracted from ice cores.

Greenhouse Gases

The tables below present characteristics of major greenhouse gases. The Global Warming Potential (GWP) indicates the warming effect of a greenhouse gas, while the atmospheric lifetime indicates how long the gas remains in the atmosphere. The vast majority of emissions are carbon dioxide followed by methane and nitrous oxide.

Greenhouse Gas	Chemical Formula	Anthropogenic Sources	Atmospheric Lifetime (years)	GWP (100 Year Time Horizon)
Carbon dioxide	CO_2	Fossil-fuel combustion, Land-use conversion, Cement production	~100	1
Methane	CH_4	Fossil fuels, Rice paddies, Waste dumps	12	25
Nitrous oxide	N_2O	Fertilizer, Industrial processes, Combustion	114	298
Tropospheric ozone	O_3	Fossil fuel combustion, Industrial emissions, Chemical solvents	hours-days	N.A.
CFC-12	CCL_2F_2	Liquid coolants, Foams	100	10,900
HCFC-22	CCl_2F_2	Refrigerants	12	1,810
Sulfur hexaflouride	SF_6	Dielectric fluid	3,200	22,800

Greenhouse Effect

When sunlight reaches Earth's surface, it can either be reflected back into space or absorbed by Earth. Once absorbed, the planet releases some of the energy back into the atmosphere as heat (also called infra-red radiation). Greenhouse gases (GHGs) like water vapour (H_2O), carbon dioxide (CO_2), and methane (CH_4) absorb energy, slowing or preventing the loss of heat to space. In this way, GHGs act like a blanket, making Earth warmer than it would otherwise be. This process is commonly known as the "greenhouse effect." Without greenhouse gases, heat energy absorbed and reflected from earth's surface would easily radiate back out to space, leaving the planet with an inhospitable temperature close to –19°C (2°F), instead of the present average surface temperature of 15°C (59°F).

Since the Industrial Revolution began around 1750, human activities have contributed substantially to climate change by adding CO_2 and other heat-trapping gases to the atmosphere.

These greenhouse gas emissions have increased the greenhouse effect and caused Earth's surface temperature to rise. Therefore, it is called **Enhanced Green House Effect.**

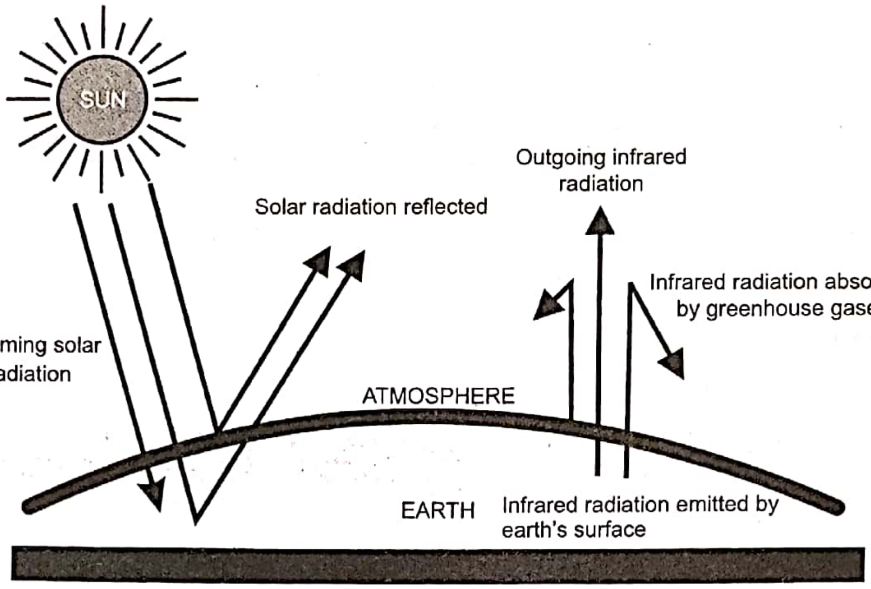

SUN
Outgoing infrared radiation
Solar radiation reflected
Infrared radiation absorbed by greenhouse gases
Incoming solar radiation
ATMOSPHERE
EARTH
Infrared radiation emitted by earth's surface

Figure: Green House Effect and Global Warming

Evidence of Climate Change

Rising global temperatures have been accompanied by changes in weather and climate. Many places have seen changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. The planet's oceans and glaciers have also experienced some big changes - oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising. As these and other changes become more pronounced in the coming decades, they will likely present challenges to our society and our environment.

Arctic sea ice loss: The decline in Arctic sea ice, both in extent and thickness, over the last several decades is further evidence for rapid climate change.

Vegetation: A change in the type, distribution and coverage of vegetation may occur given a change in the climate. Some changes in climate may result in increased precipitation and warmth, resulting in improved plant growth and the subsequent sequestration of airborne CO_2.

Pollen analysis: Palynology is the study of contemporary and fossil **palynomorphs,** including pollen. **Palynology** is used to infer the geographical distribution of plant species, which vary under different climate conditions.

Dendroclimatology: Dendroclimatology is the analysis of tree ring growth patterns to determine past climate variations. Wide and thick rings indicate a fertile, well-watered growing period, whilst thin, narrow rings indicate a time of lower rainfall and less-than-ideal growing conditions.

Ice cores: Analysis of ice in a core drilled from an ice sheet such as the Antarctic ice sheet, can be used to show a link between temperature and global sea level variations. The air trapped in bubbles in the ice can also reveal the CO_2 variations of the atmosphere from the distant past, well before modern environmental influences.

Animals: Remains of beetles are common in freshwater and land sediments. Different species of beetles tend to be found under different climatic conditions. Given the extensive lineage of beetles whose genetic makeup has not altered significantly over the millennia, knowledge of the present climatic range of the different species, and the age of the sediments in which remains are found, past climatic conditions may be inferred.

Sea level change: Global sea level change for much of the last century has generally been estimated using tide gauge measurements collated over long periods of time to give a long-term average. More recently, altimeter measurements in combination with accurately determined satellite orbits have provided an improved measurement of global sea level change.

Consequences of Climate Change

Scientists have high confidence that global temperatures will continue to rise for decades to come, largely due to greenhouse gases produced by human activities. The Intergovernmental Panel on Climate Change (IPCC), which includes more than 1,300 scientists from all over the world, forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century.

According to the IPCC, the extent of climate change effects on individual regions will vary over time and with the ability of different societal and environmental systems to mitigate or adapt to change. The IPCC predicts that increases in global mean temperature of less than 1.8 to 5.4 degrees Fahrenheit (1 to 3 degrees Celsius) above 1990 levels will produce beneficial impacts in some regions and harmful ones in others. Net annual costs will increase over time as global temperatures increase.

There is growing global consensus that climate change is humankind's greatest threat in modern times and is likely to have profound consequences for socio-economic sectors such as health, food production, energy consumption and security and natural resource management. The harmful impacts of this global warming effect are already manifesting themselves around the world in the form of extreme weather events like storms, tornadoes, floods and droughts, all of which have been mounting in frequency and intensity. As a result, the world today suffers around 400-500 natural disasters on average in a year, up from 125 in the 1980s (Disaster Risk Reduction: Global Review 2007).

According to the Fourth IPCC Assessment Report, the evidence of predicted impacts of climate change is slowly unfolding. Crop yield growth rates are declining in most parts of the world, partially as a consequence of rising temperatures, while increases in prevalence of climate-induced diseases have also been recorded. There is also evidence of accelerating recession of most glaciers on Earth, rainfall variability and changes in marine ecosystems. Another serious threat arising from climate change is to freshwater availability which is projected to decline especially in large river basins and adversely affect more than a billion people by the 2050.

Climate change is also likely to have wide-ranging and mostly adverse impacts on human health. The projected increase in the duration and frequency of heat waves is expected to increase mortality rates as a result of heat stress, especially in areas where people are not equipped to deal with warmer temperatures. To a lesser extent, increases in winter temperatures in high latitudes could lead to decreases in mortality rates.

Climate change is also expected to lead to increases in the potential transmission of vector borne diseases, including malaria, dengue, and yellow fever, extending the range of organisms such as insects that carry these diseases into the temperate zone, including parts of the United States, Europe, and Asia.

The Observed Effects of Global Warming so far are:

1. increase in the mean global sea level (1-2 mm per year over the last century);
2. increase in mean global temperature by 1.5° f in the past century;
3. loss of biodiversity and shift in vegetation.
4. worldwide retreat of glaciers;
5. decrease in snow cover and thawing of permafrost; .
6. shifts of plant and animal ranges;
7. Earlier flowering of plants;
8. birds breeding seasons and emergence of insects; and
9. increased events of coral bleaching.

How is Pakistan affected by Climate Change?

Pakistan contributes very little to the overall Greenhouse Gas (GHG) emissions, but remains severely impacted by the negative effects of climate change by the following ways:

1. Glacier melt in the Himalayas is projected to increase flooding.
2. Will affect water resources within the next two to three decades. This will be followed by decreased river flows over time as glaciers recede.
3. Freshwater availability is also projected to decrease which will lead to biodiversity loss and reduce availability of freshwater for the population.
4. Coastal areas bordering the Arabian Sea in the south of Pakistan will be at greatest risk due to increased flooding from the sea and in some cases, the rivers.
5. Being a predominantly agriculture economy, climate change is estimated to decrease crop yields in Pakistan which in turn will affect livelihoods and food production. Combining the decreased yields with the current rapid population growth and urbanization in the country, the risk of hunger and food security will remain high.
6. Endemic incidence and mortality due to diseases primarily associated with floods and droughts are expected to rise. Increases in coastal water temperatures would exacerbate the abundance of cholera.
7. The impact of climate change will also aggravate the existing social inequalities of resource use and intensify social factors leading to instability, conflicts, displacement of people and changes in migration patterns.

How to Control Climate Change

Climate change is the result of increased emissions of greenhouse gases. To control the Global warming we need to control GHG emissions. Following steps can be helpful.

1. Purchase of Energy efficient appliances such as cars and domestic appliances.
2. Adoption of 3Rs strategy that is Reduce Reuse and Recycle.
3. Use of renewable energy and production of clean energy through technology enhancement.
4. Reducing deforestation and promoting afforestation.
5. Making wise use of transport (bike, public transport)
6. Control of population explosion and resultantly less wastage of resources.

7. Creating awareness among public about the gravity of the issue.
8. Implementation of international environmental treaties such as Kyoto protocol and Montreal protocol.
9. Replace your current home appliances (refrigerator, washing machine, dish washer) with high-efficiency models.
10. Buy food and other products with reusable or recyclable packaging instead of those in non-recyclable packaging.
11. Replace incandescent light bulbs with compact fluorescent bulbs.

KYOTO PROTOCOL

The Kyoto Protocol is an international agreement under the United Nations Framework Convention on Climate Change (UNFCCC), which commits its parties by setting internationally binding emission reduction targets. The Kyoto Protocol was adopted in Kyoto, Japan, on December 11, 1997 and entered into force on February 16, 2005. To date, 192 parties have ratified the Protocol. The Convention divides countries into three main groups according to differing commitments:

Annex I: Parties include the industrialized countries that were members of the OECD (Organisation for Economic Cooperation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European states. **Non-Annex I Parties** are mostly developing countries which don't have binding targets such as China, India, and Pakistan etc.

Annex II: Parties consist of the OECD members of Annex I, but not the EIT Parties. They are required to provide financial resources to enable developing countries to undertake emissions reduction activities under the Convention and to help them adapt to adverse effects of climate change.

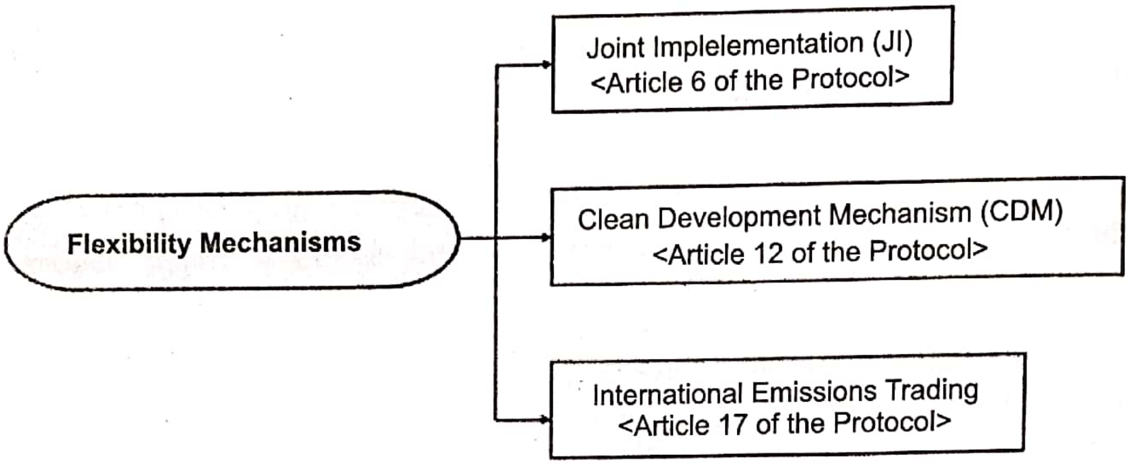
Objectives

The main goal of the Kyoto Protocol is to control emissions of the main greenhouse gases. Some of the principal concepts of the Kyoto Protocol are:

- The main feature of the Protocol is that it established legally binding commitments to reduce emissions of greenhouse gases for Annex I Parties. The commitments were based on the Berlin Mandate, which was a part of UNFCCC negotiations leading up to the Protocol.
- In order to meet the objectives of the Protocol, Annex I Parties are required to prepare policies and measures for the reduction of greenhouse gases in their respective countries.
- Minimizing Impacts on Developing Countries by establishing an adaptation fund for climate change.
- Accounting, Reporting and Review in order to ensure the integrity of the Protocol.
- Establishing a Compliance Committee to enforce compliance with the commitments under the Protocol.

Kyoto Mechanisms

The Protocol defines three **"flexibility mechanisms"** that can be used by Annex I Parties in meeting their emission limitation commitments. The flexibility mechanisms are International Emissions Trading (IET), the Clean Development Mechanism (CDM), and Joint Implementation (JI).


Flexibility Mechanisms
Joint Implelementation (JI)
<Article 6 of the Protocol>
Clean Development Mechanism (CDM)
<Article 12 of the Protocol>
International Emissions Trading
<Article 17 of the Protocol>

Emissions Trading or Carbon Trading

Parties with commitments under the Kyoto Protocol have accepted targets for limiting or reducing emissions. These targets are expressed as levels of allowed emissions, or "assigned amounts," over the commitment period. Emissions trading, as set out in Article 17 of the Kyoto Protocol, allows countries that have emission units to spare — emissions permitted them but not "used" — to sell this excess capacity to countries that are over their targets. Thus, a new commodity was created in the form of emission reductions or removals. Since carbon dioxide is the principal greenhouse gas, people speak simply of trading in carbon. Carbon is now tracked and traded like any other commodity. This is known as the "carbon trading."

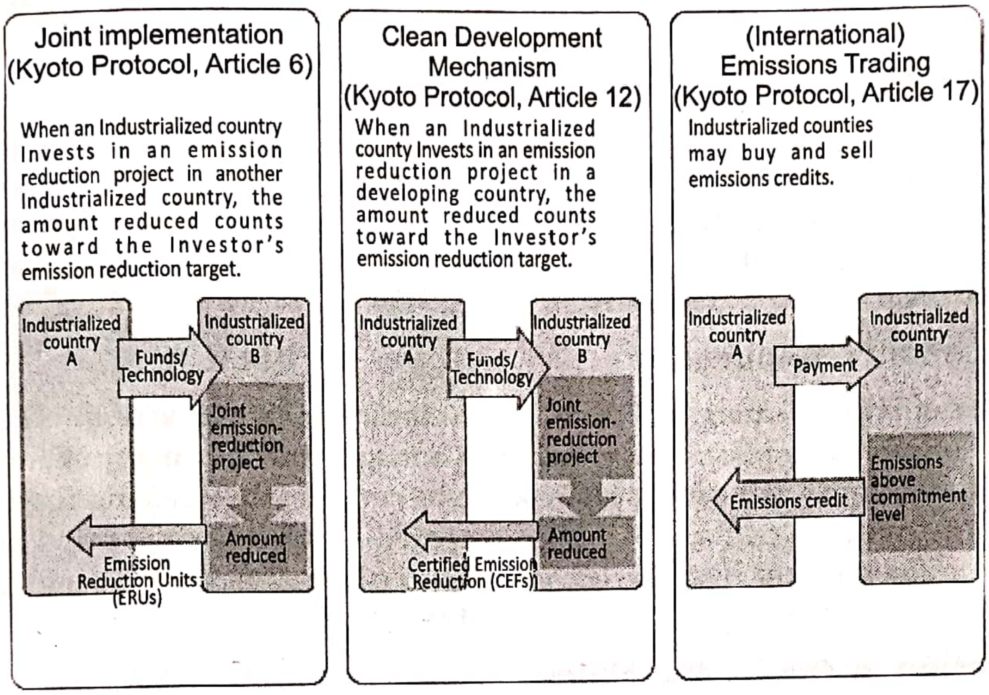
Clean Development Mechanism (CDM)

The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex II Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one ton of CO_2, which can be counted towards meeting Kyoto targets. A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy-efficient boilers. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets.

Joint Implementation

The mechanism known as "joint implementation," defined in Article 6 of the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex II Party) to earn emission reduction units (ERUs) from an emission-reduction or emission removal project in another Annex II Party, each equivalent to one ton of CO_2, which can be counted towards meeting its Kyoto target. Joint implementation offers Parties a flexible and cost-efficient means of fulfilling a part of their Kyoto commitments, while the host Party benefits from foreign investment and technology transfer.

The Kyto Protocol's flexible mechanisms



Joint implementation (Kyoto Protocol, Article 6)

When an Industrialized country Invests in an emission reduction project in another Industrialized country, the amount reduced counts toward the Investor's emission reduction target.

Clean Development Mechanism (Kyoto Protocol, Article 12)

When an Industrialized county Invests in an emission reduction project in a developing country, the amount reduced counts toward the Investor's emission reduction target.

(International) Emissions Trading (Kyoto Protocol, Article 17)

Industrialized counties may buy and sell emissions credits.

First Commitment Period (2008-2012)

Under the Kyoto Protocol, industrialized countries and the European Community committed themselves to binding targets for GHG emissions by at least 5 percent compared to 1990 emission levels during the first commitment period under the Kyoto Protocol (2008-2012). The targets apply to the four greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), and two groups of gases, hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). The six GHG are translated into CO_2 equivalents in determining reductions in emissions.

According to calculations by the European Environment Agency, total emissions of the EU member states have decreased by an average 12.2 percent during the period from 2008 - 2012 compared to 1990 levels. This means that the EU clearly exceeded its target.

The global trend, however, looks very different: up to 2010 global greenhouse gas emissions had risen by around 24 percent compared with 1990 levels. In addition to some of the industrialised countries, rapidly developing newly industrialising countries such as China and India are particularly responsible for this.

Doha Amendment and Second Commitment Period (2013-2020)

In Doha, Qatar, on December 8, 2012, the "Doha Amendment to the Kyoto Protocol" was adopted. The amendment includes: new commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020. During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first.

Shortcomings of the Protocol

In addition to having controversial flaws that impede the implementation of the Protocol, there are a number of fundamental shortcomings with the ideas behind the treaty that question its benefit as a whole.

Exclusion of Developing Countries

This shortcoming is best shown by the fact that China and India, which together represent one-third of the world's population and are growing rapidly in terms of industrial capacity, are left completely unchecked in terms of greenhouse gas emissions. If the Kyoto Protocol is to achieve its goal of reducing global emissions, it will have to be changed to include all countries of the world, each contributing accordingly.

Costs and Economic Implications

The costs of implementing the treaty, when considered in terms of direct costs, loss of jobs, and long-term economic implications, are of such a magnitude that many experts think there are far more important immediate global priorities to be considered. While no finite estimate of how much the Kyoto Protocol would cost has been prepared, projects such as providing clean water to the world's population, which would save millions of lives annually, could be realized for a fraction of the cost and have far more immediate benefits.

Non Ratification by the United States

In 2001 the world's biggest greenhouse gas emitter, the United States, responsible for 25% of the world's greenhouse-gas emissions dropped out of the Kyoto agreement. The reason was that the drastic curb on its emissions, as targeted by the Kyoto Protocol, would severely harm the country's economy. By withdrawing its support on mandatory emission restrictions, one of today's most influential countries is not acting as a good example for the rest of the world.

Kyoto Protocol Success or Failure

The Kyoto Protocol has been a failure. But it was unquestionably an important first step in global climate diplomacy. The Protocol has laid the base for such a future strategy by increasing the global awareness of the issue, stimulating research into the area of global warming, and providing an incentive for the development of science and technology to help curb emissions.

OZONE DEPLETION

Ozone is a gas made up of three oxygen atoms (O_3). It occurs naturally in small (trace) amounts in the upper atmosphere (the stratosphere). Ozone protects life on Earth from the Sun's ultraviolet (UV) radiation. In the lower atmosphere (the troposphere) near the Earth's surface, ozone is created by chemical reactions between air pollutants from vehicle exhaust, gasoline vapours, and other emissions. At ground level, high concentrations of ozone are toxic to people and plants.

Ozone Formation

Ninety percent of the ozone in the atmosphere present in the stratosphere, The natural level of ozone in the stratosphere is a result of a balance between sunlight that creates ozone and chemical reactions that destroy it. Ozone is created when the kind of oxygen we breathe—O_2—is split apart by sunlight into single oxygen atoms. Single oxygen atoms can re-join to make O_2, or they can join with O_2 molecules to make ozone (O_3). Ozone is destroyed when it reacts with CFCs.

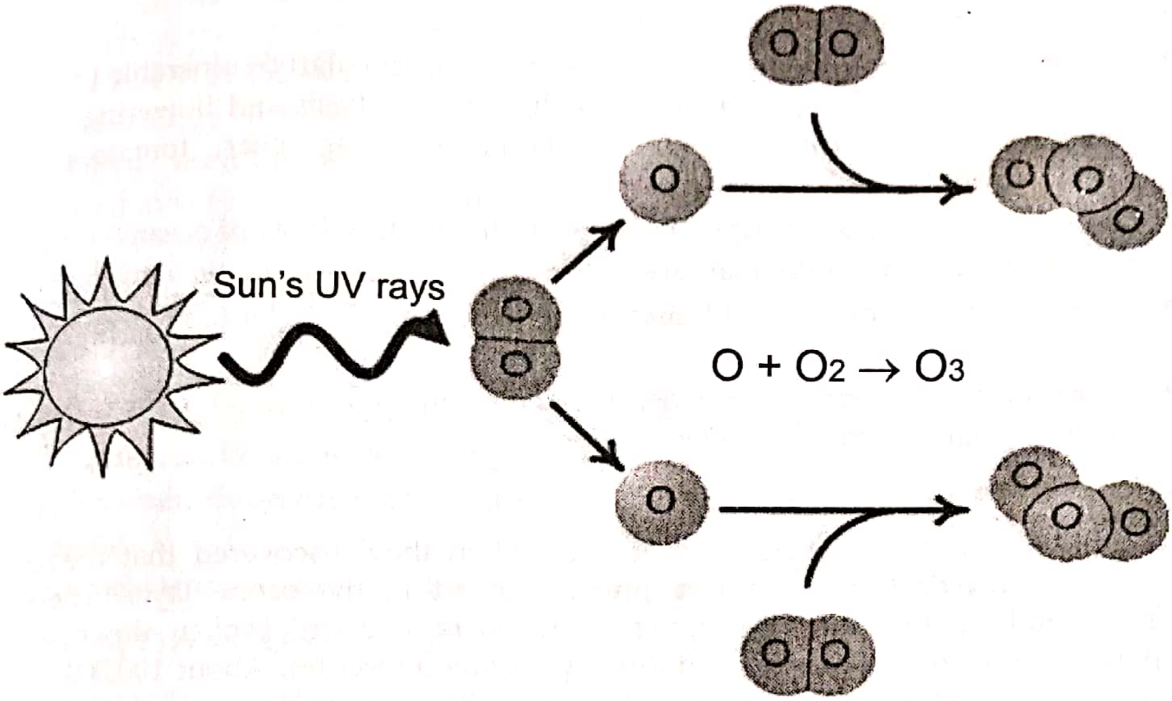
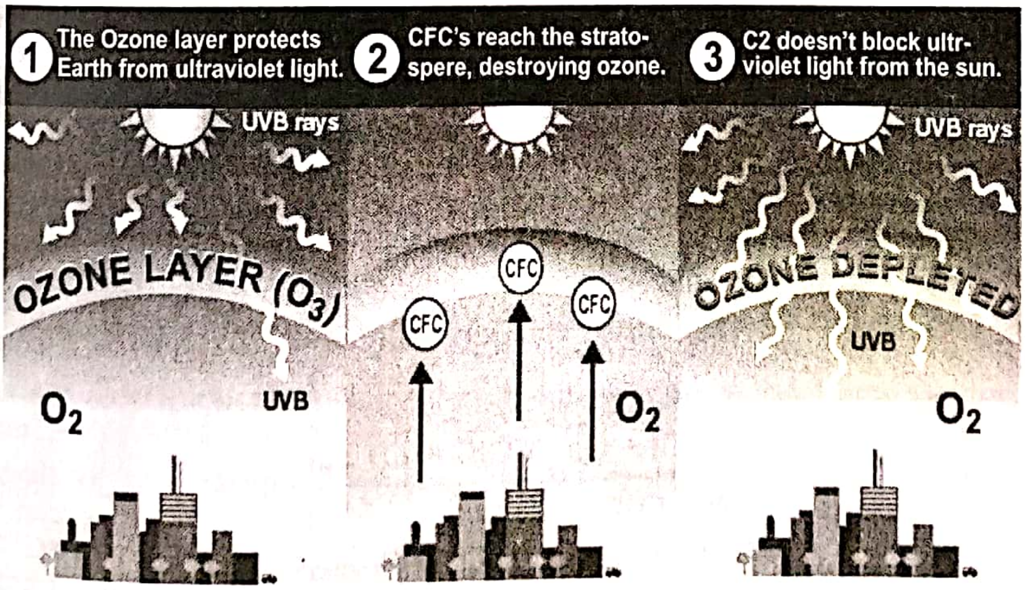


Figure: Formation of Ozone

Importance of Ozone

Ozone in the stratosphere absorbs most of the ultraviolet radiation from the Sun. Without ozone, the Sun's intense UV radiation would sterilize the Earth's surface. Ozone screens all of the most energetic, UV-c, radiation, and most of the UV-b radiation. Ozone only screens about half of the UV-a radiation. Excessive UV-b and UV-a radiation can cause sunburn and can lead to skin cancer and eye damage.


1 The Ozone layer protects Earth from ultraviolet light.
2 CFC's reach the stratospere, destroying ozone.
3 C2 doesn't block ultrviolet light from the sun.
UVB rays
OZONE LAYER (O3)
UVB
O2
CFC
CFC
CFC
O2
UVB rays
OZONE DEPLETED
UVB
O2